VOLUME 12 • NUMBER 5 • NOVEMBER, 1940

Metals and Alloys

H. W. GILLETT, Editorial Director
Battelle Memorial Institute, Columbus

EDWIN F. CONE, Editor

FRED P. PETERS, Assistant Editor
DORIS MOYNIHAN, Assistant Editor

Advisory Board

H. A. ANDERSON
Western Electric Company

WILLIAM BLUM
Bureau of Standards

A. L. BOEGEHOLD
General Motors Corporation

P. H. BRACE
Westinghouse Electric & Mfg. Co.

G. H. CLAMER
Ajax Metal Company

JUNIUS D. EDWARDS
Aluminum Company of America

O. W. ELLIS
Ontario Research Foundation

H. J. FRENCH
International Nickel Company, Inc.

JOHN HOWE HALL
Consultant

S. L. HOYT
Battelle Memorial Institute

J. B. JOHNSON
Wright Field Air Corps, War Dept.

JOHN JOHNSTON
United States Steel Corporation

JAMES T. MACKENZIE
American Cast Iron Pipe Company

R. F. MEHL
Metals Research Laboratory, C.I.T.

W. B. PRICE
Scovill Manufacturing Company

LEO F. REINARTZ
American Rolling Mill Company

H. A. SCHWARTZ
Nat'l Malleable & Steel Castings Co.

F. N. SPELLER
Consulting Metallurgical Engineer

JEROME STRAUSS
Vanadium Corporation of America

Published Monthly by Reinhold Publishing Corporation, East Stroudsburg, Pa., U.S.A. Ralph Reinhold, President and Treasurer; H. Burton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President. Executive and Editorial Offices, 330 West 42nd Street, New York. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft). Copyright, 1940, by Reinhold Publishing Corporation. All rights reserved. Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

Articles

Properties and Heat Treatment of 9 Per cent Cr—1.5 Per Cent Mo Cast Steels 615
FRED B. RIGGAN

Silver and Its Alloys in a Modern Locomotive 620
F. T. VAN SYCKEL

Metallurgical Observers in Steel Making 624
EDWIN F. CONE

Appreciation of C. A. McCune 628

Bearing Metals from the Point of View of Strategic Materials—III 629
H. W. GILLETT, H. W. RUSSELL AND R. W. DAYTON

Tin Plate and Solder—From the Strategic Viewpoint .. 641
H. W. GILLETT

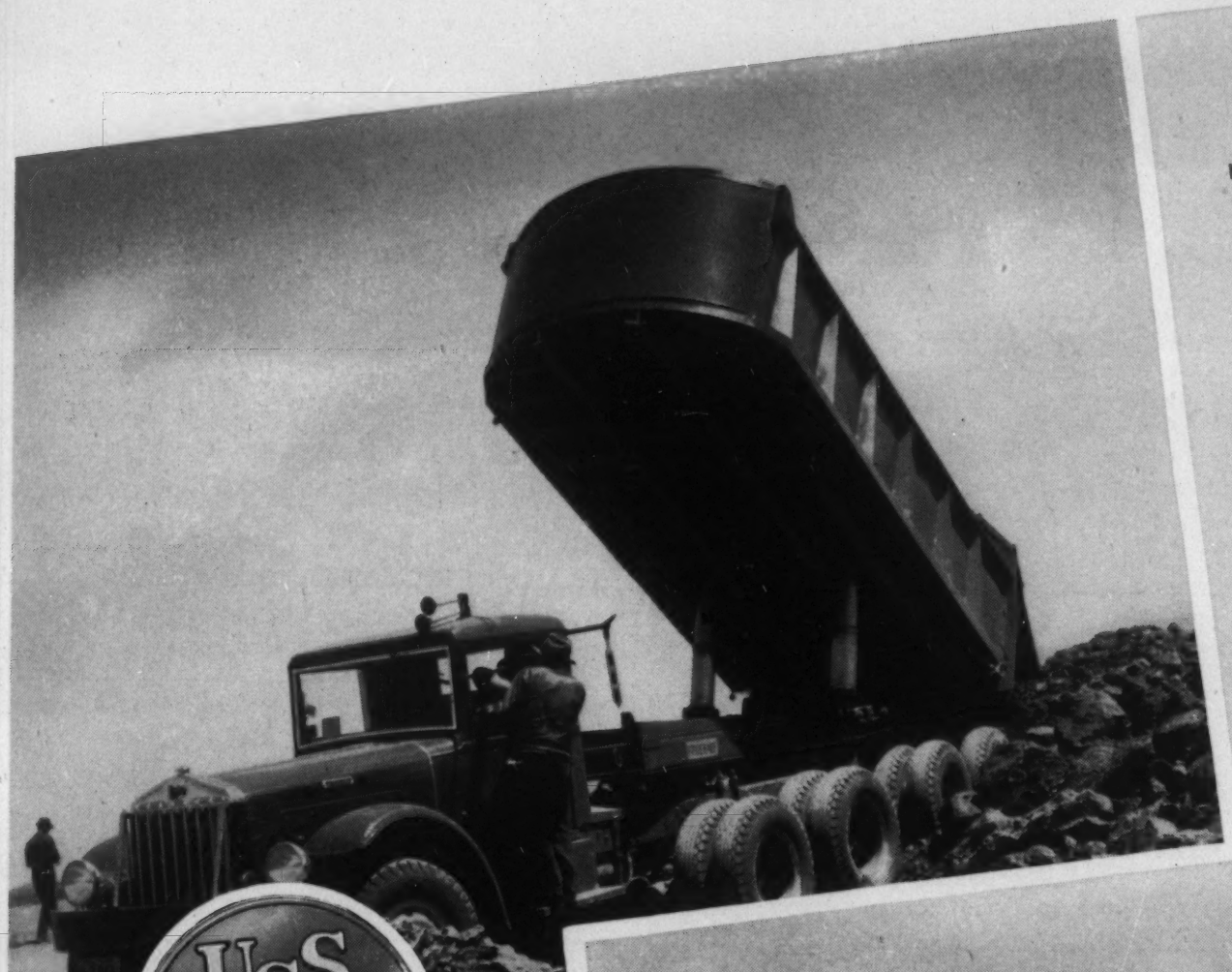
U. S. Air Corps Technical Schools 646

Manufacturers' Literature 604
Highlights 611
Editorial 613
Letter to the Editor 648
News 649
Books 704
Shop Notes 708
Advertisers in This Issue 710
Trends 712

Metallurgical Engineering Digest

Production 660
Processing and Fabrication 673
Properties and Applications 688
Testing and Control 698

U·S·S High Tensile Steels



U·S·S MAN-TEN

Is a medium carbon, medium manganese steel containing copper, and has the same resistance to atmospheric corrosion as copper-steel. It is comparable to COR-TEN in both yield and tensile strength. Its abrasion resistance is equal to that of COR-TEN and its resistance to impact and fatigue is much superior to that of mild steel. MAN-TEN'S lower price per pound recommends its use where the high corrosion resistance and other special properties of COR-TEN are not required.

• • •

Rugged construction with welded MAN-TEN throughout the structural members gives this husky 10 cu. yd. earth carrier the high resistance to wear, to shock and to distorting stresses that keeps it on the job. Weighs 16%, approximately 1500 lb., less than construction with ordinary steel.

USS MAN-TEN HIGH TENSILE STEEL

USS COR-TEN HIGH TENSILE STEEL

U·S·S COR-TEN

With a yield point approximately 1½ times that of mild steel, COR-TEN has greater tensile strength, nearly double the impact resistance and approximately 33% added resistance to abrasion. Its fatigue resistance—that is, ability to withstand vibration stresses, is 80% greater. In resistance to shock or impact at sub-zero temperatures, COR-TEN is also superior. Its resistance to atmospheric corrosion is 4 to 6 times that of ordinary steel, 2 to 3 times that of copper-steel—which assures its complete safety, long life and low maintenance cost when used in lighter sections to reduce weight.

• • •

Used here principally to insure strength and stamina, COR-TEN in the body of this 16 cu. yd. dump truck, still saves 750 lb. or 12.6% weight. Working under a 2½ yard shovel in heavy dirt and rock, these COR-TEN bodies are showing remarkable resistance to impact.

AMERICAN STEEL & WIRE COMPANY, *Cleveland, Chicago and New York*
CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
NATIONAL TUBE COMPANY, *Pittsburgh*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
Scully Steel Products Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL

Feature Section

High Cr-Mo Steel Castings

Comparison of the anti-corrosive properties of the higher Cr, higher Mo cast steels with the conventional lower Cr-Mo compositions is in favor of the 9½ Cr, 1½ Mo type for certain applications, says Mr. Riggan.

Silver Alloys in Modern Locomotives

The extent to which silver and its alloys is essential in perfecting many of the intricate parts of a modern steam-electric locomotive is emphasized by Mr. Van Syckel.

Metallurgical Observers

A typical example of the importance of a corps of metallurgical observers in regulating the essential operations of a large steel plant is discussed by the editor. Republic's practice is similar to that of other large steel companies.

Metals for Bearings

The third installment of this highly important review with special reference to the strategic metal situation supplements and continues the discussions in September and October.

Tin Plate and Solder

Continuing our series of articles on Metallurgical Engineering in Preparedness and Defense, we present a discussion by our editorial director of the importance of solder in our daily life and the relation of tin to this material, the quantity necessary and possible substitutes.

Technical Air Corps Schools

The role of the U. S. Air Corps Technical Schools in preparedness is emphasized by a few pictures.

Engineering Digests

Flash!

One doesn't have to be a Winchell (fortunately) to foresee considerable future benefit for the steel industry in the flash welding of steel strip as described by Cooper (page 660).

Ductile Titanium

Titanium has been added by Kroll (page 668) to the roster of hard-to-purify metals that he has succeeded in preparing in ductile form.

Induction Heating All-the-way-through

The special advantages of *surface* hardening by induction heating have brought great expansion in the application of this type of heating. The field is barely scratched, however, says Blasko (page 678), who emphasizes the applicability of *all-the-way-through* heating by lower-frequency induction methods.

Welding Cast Iron

More difficult than the theoretician imagines, but not so tough as the welder pretends, the problem of welding cast iron has been solved in many ways. Some of them are discussed in a composite on page 680.

Boiler Corrosion

A new "embrittlement detector" employed by Schroeder, Berk & O'Brien (page 692) has demonstrated the validity of earlier German claims for the superior resistance of properly-made steels of the Izett type to boiler corrosion-cracking.

Anodized Film Thickness

A non-destructive method of determining the thickness of anodic oxide films on aluminum (by measuring their electrical insulating value) is described by Compton & Mendizza (page 700).

DEFENSE "BOTTLE-NECKS"

REVERE TECHNICAL ADVISORY SERVICE

In many plants and industries, Revere Technical Advisory Service men are working shoulder to shoulder with executives and engineers in solving defense problems by selecting a suitable type and form of copper or one of the many copper base alloys.

These are picked men, with broad backgrounds in metal-working methods, plus highly specialized knowledge of copper and copper base alloy characteristics and applications. They are supported in this work by the full cooperation of the Revere Research Laboratories and Revere Mills.

This Technical Advisory Service comprises a thoroughly equipped Research Laboratory, manned by engineers and metallurgists for (1) developing new and better Revere materials to meet active or anticipated needs of industry; (2) supplying specific and detailed knowledge of the properties of engineering and construction materials; and (3) continuously observing developments of science and engineering with a view to their utilization in the improvement of Revere production methods and equipment.

In addition a corps of technical men are available to (1) help industrial executives make use of data developed by the Revere research laboratory staff; (2) perceive the material problems existent in industrial plants contacted; (3) assemble data enabling Revere research laboratory men to study these problems; and (4) make practical tests of the materials recommended in the plants concerned.

This Revere Technical Advisory Service set-up has been very successful in reducing costs, improving products and increasing the output for many industrial concerns.

Its service is available to you with no expense or obligation on your part.

MANY manufacturers entrusted with defense orders depend on sub-contractors for special parts. A "bottle-neck" for the sub-contractor becomes a "bottle-neck" for them. In the past four months, Revere has been able to eliminate not only many primary "bottle-necks" but many sub-contractors' "bottle-necks" too.

The Technical Advisory Service of Revere Copper and Brass Incorporated has been most helpful in cooperating with manufacturers in successfully stepping up production, reducing costs, and eliminating processing steps.

Revere is also equipped to furnish semi-finished parts such as cartridge cups and discs, rotating bands, forgings and industrial extruded shapes, in addition to the usual mill products such as rods, strips, sheets, or tubes. The services of Revere as well as its products are at your call.

REVERE

COPPER AND BRASS INCORPORATED

Executive Offices:
230 Park Avenue, New York, N. Y.

Sales Offices and Distributors in most of America's major cities

MILLS: BALTIMORE, MD. • TAUNTON, MASS. • ROME, N. Y.
NEW BEDFORD, MASS. • DETROIT, MICH. • CHICAGO, ILL.

The Low-Alloy etc. Steels

The group of steels commonly termed "low-alloy, high yield strength" steels, comprising those individually known by trade names such as Cor-Ten, Double Strength, Hi-steel, H. T. 50, N.A.X., Mayari R, Yoloy, Otiscoloy, etc., etc., is slowly but surely finding its place in American industry.

With increasing use, steady advertising of and increasing consumer interest in such steels, they are coming to the attention of many who are unfamiliar with their history. The long and clumsy phrase used to characterize them as a class does not clearly differentiate them, in these unfamiliar minds, from the moderately alloyed steels designed for heat treatment. The pricing of the low-alloy, high yield strength steels which are to be used as-rolled, without heat treatment, is justifiably on a different basis from that of the heat-treatable class for automotive and like uses, which fact has caused misunderstandings between producer and user in some cases.

It would be helpful if the potential users could be more painlessly apprised that the low-alloy, high yield strength steels are potentially quantity production steels, made in much the same way as tonnage low carbon steels, and have in large degree the formability and weldability of such carbon steels, are not intended for nor requiring heat treatment, and differ almost solely in their greater strength with, in some cases, increased resistance, against certain types of corrosion.

The strength feature has been sufficiently emphasized. It is the similarity to a certain class of carbon steel that needs emphasis.

For this class of carbon steel we have no very precise word in common use, but the British have a word for it—"mild" steel, a word with which Americans are generally acquainted, although we do not make much use of it. Even if one is not familiar with the word, it inherently carries a fairly clear idea of what it is meant to convey—a steel amenable to forming and welding, not hard nor brittle, and generally of a good disposition.

Would not the term "mild alloy-steel" well connote the characteristics of the low-alloy, high yield strength steel class and make for precision as well as brevity?—H.W.G.

Designing for Powder Metallurgy

As reported in our October issue, (page 471) the recent Boston conclave of practically all the leaders in the powder metallurgy field not only signalized a new unity of purpose among its practitioners but indicated quite specifically what its destiny might be.

The molding of metal powders has been employed chiefly to manufacture products that are impossible, inconvenient or prohibitively uneconomical to make by conventional methods. Now, however, powder metallurgy is invading the domains of other fabricating processes, and its products, because of better quality or lower manufacturing cost or both, are replacing similar products formerly made by casting-and-machining. The advocates of powder metallurgy foresee powder compacts taking their place beside iron castings, die castings, etc., where they must challenge the consideration of every engineer seeking the best metal-form or fabricating process to use for his product.

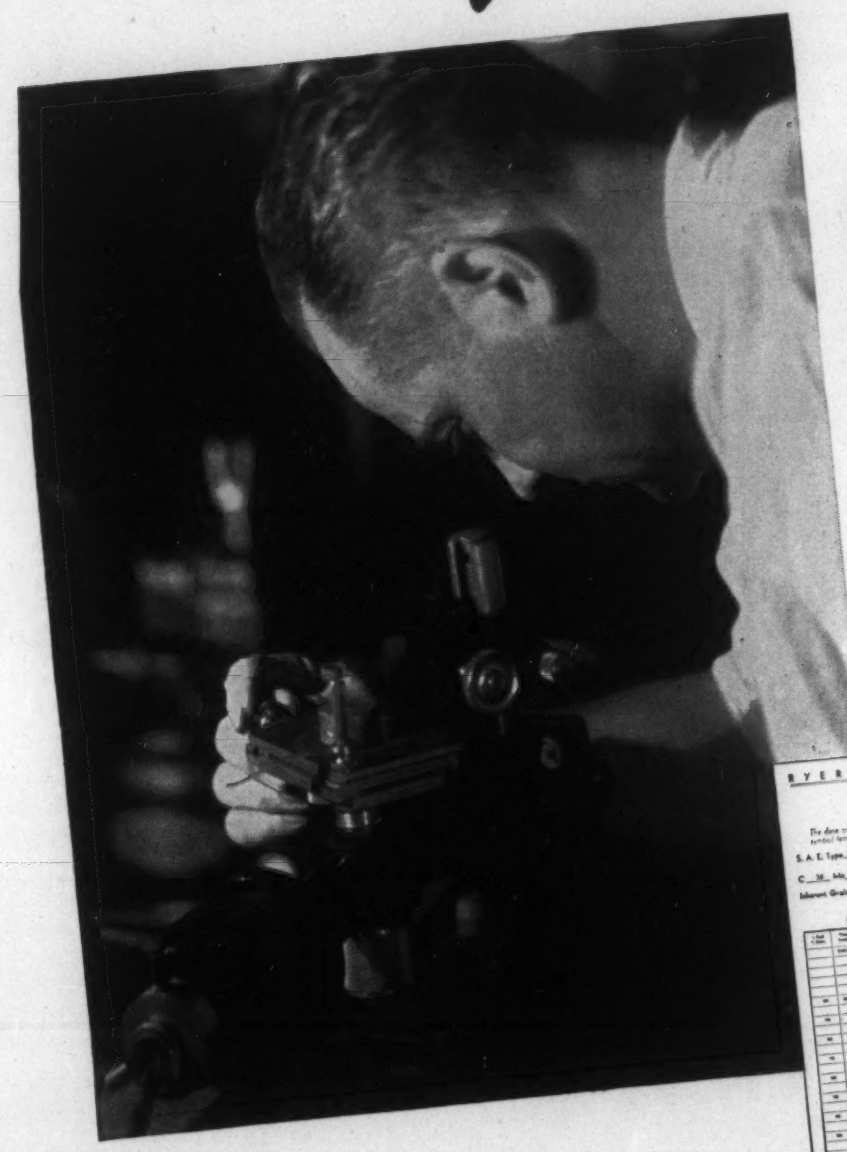
Now this idea is not new. It has long been obvious that molding a powder mass to finished shape saves machining costs, and that the process would compete eventually for relatively small, accurately-dimensioned products required in large quantities—*provided raw material powders (particularly iron) of good moldability and attractive prices become available, the mechanical properties of compacts are improved, and press and die design and materials are bettered to remove present size, shape and cost limitations.* All of these necessary conditions are being rapidly approached and the more conservative folk in the powder metallurgy field have now "made it unanimous" by officially recognizing that many of the bars are down.

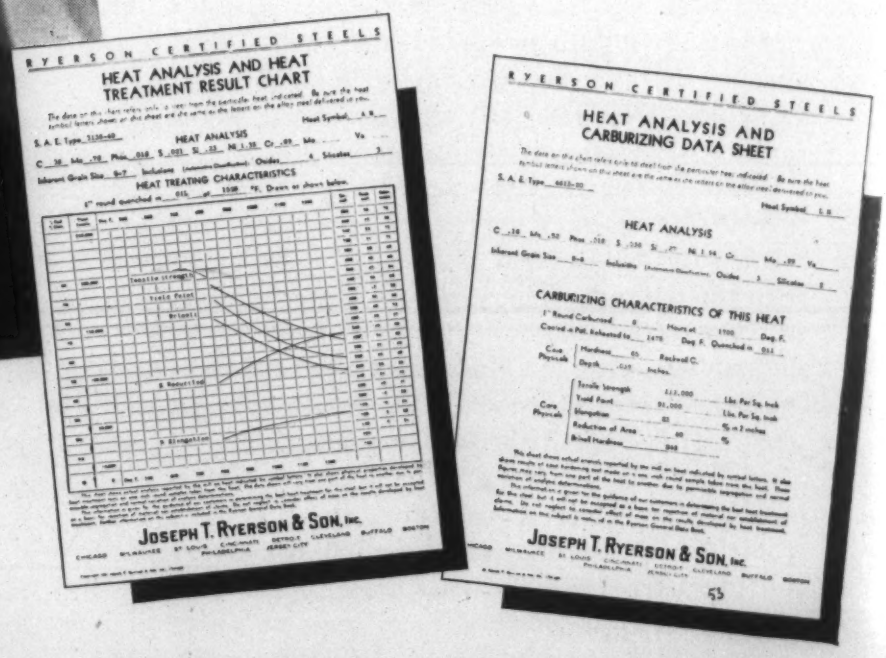
But what *is* new is the well-founded observation of E. S. Patch of Moraine Products Division of General Motors Corp., and a few others who share his indomitable faith in the future of powder metallurgy as a competitive fabricating process, that industry needs designers who are familiar with the dimensional and structural factors and changes characteristic of pressing and sintering and who are accustomed to thinking in terms of powder practice, powder compacts and their suitability as compared to competitive metal-forms for a given product. The

(Continued on page 648)

Buy Steel

with LABORATORY CERTAINTY -at Ryerson




RYERSON CERTIFIED STEELS
HEAT ANALYSIS AND HEAT TREATMENT RESULT CHART
HEAT ANALYSIS
HEAT TREATING CHARACTERISTICS
JOSEPH T. RYERSON & SON, INC.
RYERSON CERTIFIED STEELS
HEAT ANALYSIS AND CARBURIZING DATA SHEET
HEAT ANALYSIS
CARBURIZING CHARACTERISTICS OF THIS HEAT
JOSEPH T. RYERSON & SON, INC.

EVERY shipment of alloy steel is accompanied by accurate data based on laboratory tests, covering exact chemical and physical properties, grain size, cleanliness rating and hardening characteristics. With the Ryerson data sheet before you, you know what steel you are getting, you secure best heat treatment results and you save time because you do not have to test.

Ryerson stocks also include a wide range of stainless, heat- and corrosion-resisting steels, sheets and tubing—all closely controlled as to chemical content. Many highly specialized steel requirements can be supplied on a moment's notice!

Ryerson Steel-Service is geared particularly to the needs of defense industries. All Ryerson products are painstakingly selected for their uniform high quality. They are carefully warehoused, accurately cut to your specifications, and shipped on the dot from ten convenient stocks of over 10,000 sizes, kinds and shapes.

Submit your next steel problem to the nearest Ryerson plant. If you haven't the 1940-41 Ryerson stock list and data book, send for it today. It will quickly become your guide to quality steel and fast steel service.

Joseph T. Ryerson & Son, Inc., Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Cleveland, Buffalo, Boston, Philadelphia, Jersey City.

RYERSON CERTIFIED STEELS

RYERSON

Properties and Heat Treatment of 9 Per Cent Cr-1.5 Per Cent Mo Cast Steels

BY FRED B. RIGGAN
Metallurgist,
Key Co., East St. Louis, Ill.

THE INCREASING USE OF CHROMIUM in alloy steels for oil refinery equipment is a direct result of the analysis of ultimate cost of protection over a period of years. These figures are taken from operating data including original costs of material, durability, reliability and cost of replacement. It is interesting to note that one item of cost that is being reduced in spite of increasing severity of service is that of incidental damages resulting from failure. This improvement is due to intelligent periodic inspection and greater reliability of material used in the equipment.

Two other important facts seem to stand out in these studies: (1) Corrosion is the most important in the destruction and early retirement of oil refinery fittings in service up to 1200 deg. F., and (2) chromium is the most effective element in resisting this corrosion at these temperatures.

The company with which the writer is connected produces oil refinery fittings exclusively—and over 80 per cent of its tonnage is chromium alloy castings. It may be of interest, historically, to note that this plant is located in sight of one of the very first intentional applications of this alloy. This is the famous Eads Bridge across the Mississippi River at St. Louis. This structure (Fig. 1) was completed in 1874. A sample taken from one of its structural members analyzed 0.62 per cent Cr. Fig. 2 shows a group of castings made of one of the latest developments of this alloy for oil refinery use. This 9 per cent Cr-1½ per cent Mo cast steel was developed as an intermediate alloy between the 18-8 and the 5 per cent Cr-½ per cent Mo steel.

The results of Mr. Newell of Babcock & Wilcox Tube Co. on wrought material of this general analysis were published in *Metal Progress* for February, 1936. Further data were also presented by Mr. Fleischmann of the Timken Roller Bearing Co. at the Western Petroleum Refiners Association at San Antonio, Texas, March, 1939. The purpose of this paper is to give laboratory and field test results obtained during the manufacture of considerable tonnage to the 9 per cent Cr steel castings.

Four Typical Heats

In Table I are four groups of four typical heats, each listed according to carbon content. These castings were given a normalize and draw heat treatment in furnaces especially designed for normalizing castings of this type. (See Fig. 3.) Charpy impact tests at room temperature were run on bars that had been repeatedly heated and cooled according to the following cycles:

Group 1: These bars were placed in electric muffle furnace at 800 deg. F., where they were held for 1 hr. The bars were then withdrawn from the furnace, placed on a normalizing rack and cooled to room temperature. After the bar had reached room

Table I—Room Temperature Properties of 9 Per Cent Cr-1.5 Per Cent Mo Cast Steel

Per Cent				Tensile strength, Lbs. per sq. in.	Yield point, Lbs. per sq. in.	Elongation in 2 in.	Red. of area, Per cent	Brinell No.
C	Mn	Cr	Mo					
0.147	0.55	9.80	1.50	94,000	65,000	27	60.6	202
0.140	0.48	9.35	1.53	91,500	65,000	26.5	65.0	187
0.145	0.60	9.15	1.56	87,500	59,000	30	62.0	187
0.141	0.58	9.00	1.48	94,000	68,000	26	62.0	202
0.129	0.60	8.95	1.45	92,000	62,400	25.5	54.0	187
0.137	0.52	8.55	1.40	85,000	57,000	26	52.0	187
0.122	0.75	9.15	1.55	89,000	57,200	26	54.5	179
0.126	0.58	8.85	1.52	82,300	50,000	29.5	50.5	179
0.108	0.75	9.15	1.55	88,000	60,050	26	55	179
0.100	0.68	8.60	1.42	92,000	65,500	27	61	197
0.105	0.74	9.40	1.52	92,500	66,000	26	60	187
0.102	0.72	8.75	1.45	93,900	69,050	27.5	63	192
0.079	0.74	8.70	1.40	88,800	68,300	27.5	67	179
0.080	0.74	8.75	1.55	92,100	66,800	25.5	63	187
0.079	0.68	8.85	1.50	91,050	64,500	29	61	183
0.080	0.74	9.15	1.48	89,500	61,200	26	60	183

Fig. 1. The famous Eads bridge across the Mississippi River at St. Louis, Mo.

temperature, it was placed in the furnace at 800 deg. F. and the complete cycle repeated. This cycle was repeated until the bar had received 50 such treatments. The impact result on this group was 33 ft.-lbs.

Group 2: These bars received 50 complete cycles identical with Group 1 except that the temperature of the furnace in this case was 900 deg. F. The impact result on this group was 36 ft.-lbs.

Group 3: These bars received 50 complete cycles identical with Group 1 except the temperature of the furnace in this case was 1000 deg. F. The impact result on this group was 36½ ft.-lbs. The original material had an impact of 33 ft.-lbs.

Physical properties at different draw temperatures were obtained on bars selected from the same heat of steel used in the high temperature tests shown later. See Table II. The Charpy type simple beam instrument was used with the keyhole notched specimens. The initial energy of the blow was 120 ft.-lbs. with striking velocity of 18.1 ft. per sec. Weight of pendulum was 23.57 lbs.

The test specimens were machined to bars 1 in. x 1 in. x 5 in. and heat treated simultaneously in an automatically controlled muffle furnace. The samples were normalized at 1550 deg. and tempered as indicated. These bars were then machined to the regular 0.505 dia. tensile test specimens. These results show that the tensile strength and the hardness of the steel were decreased and the ductility increased as the tempering temperature was raised from 1100 deg. to 1400 deg. F. The physical properties at elevated temperatures are shown in Table III. The bars cut from same test block were held at temperature 20 minutes before applying the load at the rate of 0.12 in. per minute (head speed) and this temperature was maintained throughout the entire period of testing. The bar from which these test specimens were machined had previously had the following heat treatment:

> Step normalize by heating to 1550 deg. F. for 7 hrs.; raise to 1750 deg. F. for 1 hr., and then air cool.
>
> Draw at 1250 deg. F. for 5 hrs.; cool in furnace to 600 deg.

The specimens pulled at 1050 deg. F. were slightly less ductile than those pulled at 900 deg. F. and 1200 deg. F. These results are considerably higher than the published results on corresponding wrought material.

The Corrosion Tests

Comparative corrosion tests were made on carbon steel, 5 per cent Cr-½ per cent Mo, and 9 per cent Cr-1½ per cent Mo cast steels. The polished specimens 1½ x 1 x ½ in. were exposed at room temperature to sea water spray, immersed in aerated 2 per cent sulphuric acid solution, and also aerated 20 per cent nitric acid solution. The results of the corrosion tests are summarized in Table IV. This table shows the relative corrosion resistance between cast carbon steel, cast 5 per cent Cr-½ per cent Mo, and cast 9 per cent Cr-1½ per cent Mo, in three corroding media. The addition of chromium enhances the corrosion resistance in oxidizing media. In reducing media its effect may be just the reverse. These phenomena follow well established physical laws.

Before attempting to comment on the results shown in this table we would like to mention that we think it possible to get very valuable practical information on the way corrosion works but the following of the various theories involved to their ultimate end may interfere with his practical decisions."

The corrosion resistance associated with chromium-bearing steels is not affected by the addition of chromium *per se* but rather is attributed to a complex, refractory chromium-bearing oxide which forms on these steels in oxidizing media (as in the 20 per cent nitric acid solution). In the aerated

Table II—Physical Properties of a Cast 9 Per Cent Cr-1.5 Per Cent Mo Steel after Normalizing and Tempering as Indicated

Sample Number	Heat Treatment	Yield point, Lbs. per sq. in.	Max. stress, Lbs. per sq. in.	Elong. in 2 in., Per cent	Red. of area, Per cent	Brinell Hardness number
1A	Held 3 hrs. at 1100 deg. F., air cooled	67,000	99,000	20.5	54.4	212
1B	Held 3 hrs. at 1100 deg. F., air cooled	53,500	87,000	23.5	59.4	187
2A	Held 3 hrs. at 1200 deg. F., air cooled	55,000	86,500	25.0	59.6	183
2B	Held 3 hrs. at 1200 deg. F., air cooled	47,000	79,500	24.5	58.3	170
3A	Held 3 hrs. at 1300 deg. F., air cooled	51,000	83,000	27.0	64.7	170
3B	Held 3 hrs. at 1300 deg. F., air cooled	52,000	84,500	30.0	63.3	179
4A	Held 3 hrs. at 1400 deg. F., air cooled	47,000	78,750	29.0	64.7	170
4B	Held 3 hrs. at 1400 deg. F., air cooled	46,000	79,500	30.0	61.6	163

Table III—Physical Properties at Elevated Temperatures of a Cast 9 Per Cent Cr-1.5 Per Cent Mo Steel after Normalizing and Tempering at 1200 deg. F.

Sample Number	Test temperature in deg. F.	Maximum stress, Lbs. per sq. in.	Elong. in 2 in., Per cent	Reduction of area, Per cent
1	900	76,000	20.0	53.0
2	1050	66,000	17.0	52.2
3	1200	54,250	19.0	61.3

Fig. 2. Above: A group of castings made of the 9½ Cr, 1½ per cent Mo steel.

Fig. 3. Right: Heat-treating furnace specially designed for normalizing these 9.5 Cr, 1.5 per cent Mo castings. A hot charge is being withdrawn.

dilute sulphuric acid solution the hydrogen evolved by dissolution of the 5 per cent Cr steel probably outweighed the effect of the oxygen introduced in aeration and under the resulting reducing condition the protective film did not form and thus passivity to this particular corrosive agent did not develop. It appears that the balance of these opposing factors favored film formation more in the 9 per cent Cr than in the 5 per cent Cr steels.

The ionization varies with the reagent concentration so that a low chromium steel may be more resistant than a mild steel in 0.05 sulphuric acid but less resistant in 0.5 per cent sulphuric acid. We can only comment that, due to the extreme complexity of the corrosion phenomena, we are not trying to explain results in Table IV, but are simply calling attention to the results obtained in those media. It is of interest to note that in all solutions the 9 per cent Cr-1½ per cent Mo was far more resistant than the 5 per cent Cr-½ per cent Mo steel.

Actual Service Results

Comparative results on these two cast steels in actual service bear out this improvement of the higher chromium steels. In one particular application having severe corrosive conditions with temperatures around 950 deg. F. in Southern California, the average life of 5 per cent Cr-½ per cent Mo cast steel was 6 months. (See Fig. 4.) In some instances the corrosion was as much as ¼ in. reduction in wall thickness in 750 hrs. Nine per cent Cr-½ per cent Mo was substituted on this same job and the report after 1000 hrs. service was "no corrosion." After more than 6000 hrs. service to date there is no visible evidence of corrosion on these castings and no loss in weight can be detected by the purchasers' inspectors. This seems to be one of those cases where the alloy used happens to be just right for the particular service encountered and as yet we are not able to explain the apparently complete passivity of this material in this extremely corrosive service.

Comparative Costs

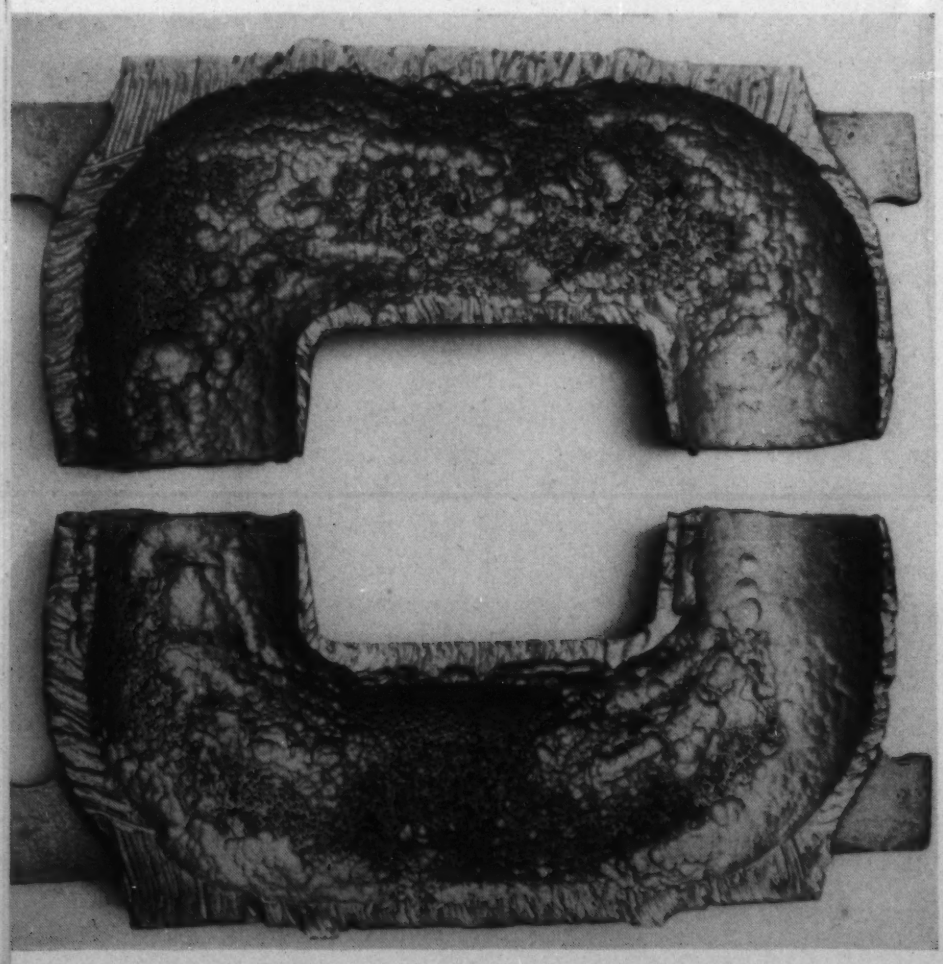
The comparative costs of these alloy castings, using cast carbon steel as a basis, with cost equal to 100 units on one particular job studied was:

5% Cr, ½% Mo — 125 units
9% Cr, 1½% Mo — 168 units

As yet we do not have sufficient data on corrosion rates of the actual 9 per cent Cr-1½ per cent Mo castings in service to give specific service costs.

For the past 18 months we have been sending out corrosion strips prepared in accordance with the American Petroleum Institute Code. These strips

Fig. 4. Left: A corroded 5 per cent Cr, 0.50 per cent Mo casting after 6 months' service. Casting is split to show corroded areas. Fig. 5. Right: The whole casting of Fig. 4 before it was split.



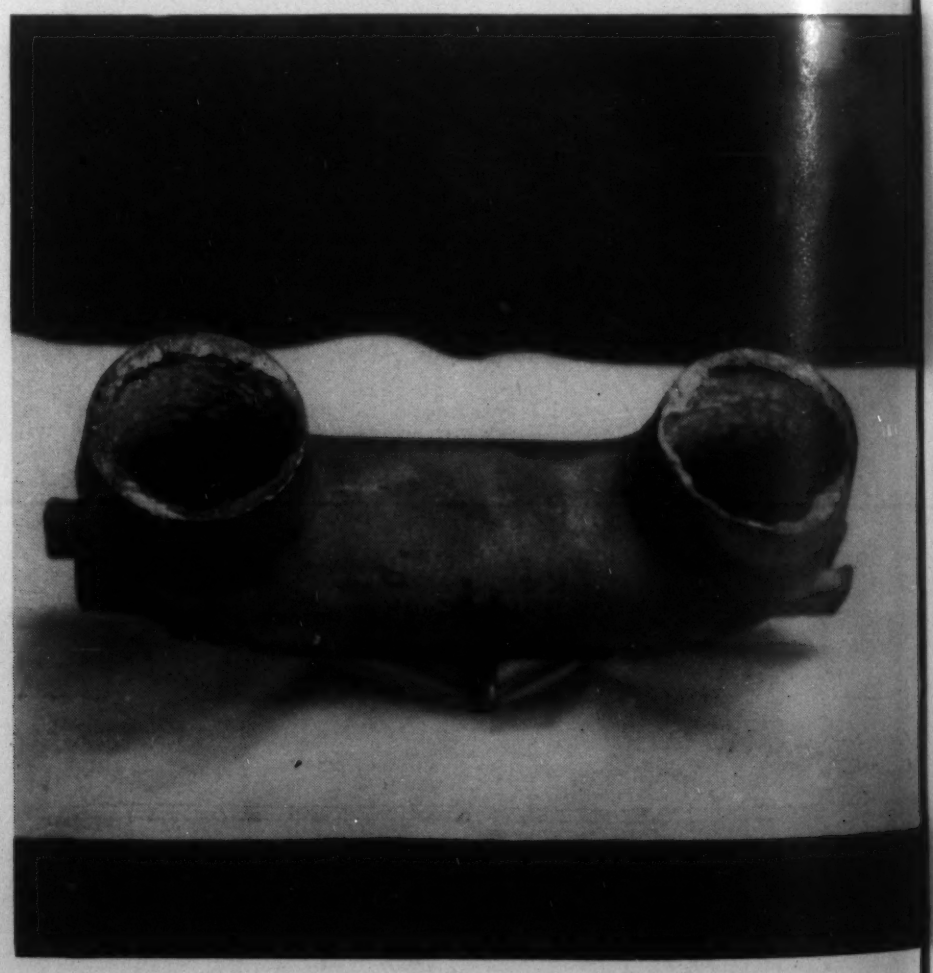


Table IV—Results of Corrosion Tests on Plain Carbon; 5 Per Cent Cr-½ Per Cent Mo, and 9 Per Cent Cr-1.5 Per Cent Mo Steels in various Media. All Tests made at Room Temperature.

Type of Test	Period	Duration of Test in Hrs.	Rate of Attack in Inch Penetration per Month: Plain Carbon Steel Sample 1	Plain Carbon Steel Sample 2	5 Cr, 0.50% Mo Steel Sample 1	5 Cr, 0.50% Mo Steel Sample 2	9 Cr, 1.50% Mo Steel Sample 1	9 Cr, 1.50% Mo Steel Sample 2
Sea water spray	First	113	0.00147	0.00131	0.00064	0.00073	0.0002	0.0002
	Second	115	0.00131	0.00131	0.0006	0.00062	0.000194	0.00017
Aerated aqueous 2 per cent sulphuric acid solution	First	43	0.019	0.01820	0.122	0.113	0.052	0.0455
	Second	47	0.0127	0.0151	0.119	0.117	0.0445	0.0382
Aerated aqueous 20 per cent nitric acid solution	First	3	11.5	11.8	11.5	10.6	0.0356	0.035

of carbon steel, 5 per cent Cr-½ per cent Mo, and 9 per cent Cr-½ Mo are held in the oil stream under actual service conditions of temperatures. One report shown below covers strips exposed in a Dubbs unit operating with Venezuelan crude oil.

Testing Conditions:

	31A	*31B*	*31C*	*31D*
Duration, days	7	15	11	25
Temperature (deg. F.)	785	610	575	555
Intake light oil furnace, tons per 25 hrs.	985	550	690	690
Sulphur content of intake, per cent	1.5	0.38	0.55	0.4

Loss of weight (grams)	*31A and 31B*	*31C*	*31D*
Cast 8.55 Cr, 1.4 Mo	0.73	0.11	1.52
Cast 8.85 Cr, 1.52 Mo	0.68	0.05	1.78
Cast 5.05 Cr, 0.52 Mo	3.08	1.10	5.56
Cast carbon steel	18.57	2.21	8.93
Corrosion rates (mm. per yr.)			
Cast (8.55 Cr, 1.4 Mo)	0.14	0.03	0.26
Cast (8.85 Cr, 1.52 Mo)	0.13	0.03	0.30
Cast (5.05 Cr, 0.52 Mo)	0.61	0.43	0.96
Cast carbon steel	3.65	0.86	1.54

The test was carried out during four periods of operations (runs 31A, B, C and D respectively), losses of weight have been determined after run 31 (A and B), after run 31C and after run 31D. Before re-weighing the samples were cleaned with citric acid and by mold rubbing.

It was evident that conditions during periods C and D were such that a mild corrosion by naphthenic acid was prevailing and that for this lower temperature range the relative merit of higher chromium content is not so pronounced. The information we have received on these strips indicates that in general the average relative corrosion resistance, considering carbon steel as 100 units, would be: 5 per cent Cr-½ per cent Mo approximately 300 units and the 9 per cent Cr-1.50 per cent Mo in excess of 700 units.

Steel castings of the 9 per cent Cr-1.50 per cent Mo type have somewhat different microstructures than the wrought materials with similar analysis and heat treatment. Since the casting is usually ordered to a higher strength and Brinell than rolled material such as tubes, etc., slightly higher carbons and, to a certain extent, lower molybdenums are indicated. This is due to the fact that molybdenum and chromium, being gamma loop formers, contribute to the presence of fairly large areas of delta iron in the microstructures of 9 per cent Cr castings when the molybdenum exceeds 1.25 per cent. Although castings having large areas of this delta ferrite in its matrix show good physical properties and are giving good service in the field, it is believed that, from a standpoint of microstructure and impact (on small specimens), a 0.25 per cent max. carbon specification with molybdenum between 1 and 1.25 per cent would further improve the above cast steels in the normalized and drawn condition.

The two cast steels with identical normalize and draw treatment shown below demonstrate the pronounced effect of molybdenum on delta ferrite formation.

	Carbon	Chromium	Molybdenum	Tensile	Yield	Elongation	Red. of Area	Brinell	Micro-structure
A	0.16	9.30	1.36	93,000	65,000	27	62.6	187	100X
B	0.10	8.90	1.78	82,000	53,000	31	73.0	175	100X

The writer wishes to acknowledge his appreciation to D. B. Reeder of the Electro Metallurgical Co. for running the tests at elevated temperatures and to Messrs. Hoestetter and Timmons of the Climax Molybdenum Co. for the repeated heating and cooling cycles run on our specimens.

The General Electric Steam Electric Locomotive: Capable of hauling 12 Pullman cars at speeds of 110 m. p. h. and up to 125 m. p. h. where traffic permits. It will do twice the work of conventional type locomotives for each pound of fuel used. It can run 500 to 700 miles without making a stop. It crosses the hardest grades over the Rockies without help. It uses electricity in braking. The distilled water it uses eliminates corrosion and boiler scale. It is made in two units, each weighing about 265 tons. It operates on 1500 lbs. per sq. in. steam pressure. The total horsepower is 5000 and each unit is 90 ft. long.

Silver and Its Alloys

ALMOST EVERYONE, in reading about or actually looking over the new General Electric steam electric locomotive recently built at their Erie Works for the Union Pacific Railroad, will be amazed at its size, power, speed and the details about its economy of operation. The idea behind the operation of this new engine is to generate steam rapidly in a high pressure oil-fired boiler and use it to drive a turbo-generator set which supplies the current for driving the traction motors of the locomotive and also to operate all auxiliaries and heat and light the train being hauled.

One hears about the tons of steel and copper that have gone into the make-up of this engine; about the important part modern alloy steels and light weight alloys of various types play in its construction and about welding and how it has revolutionized construction for so many purposes.

Few, however, will realize, unless they dig deeply into details, how widely silver and its alloys have been used to attain reliable operation in vital spots.

Between the front headlights and the rear coupling of this locomotive there are literally hundreds of

n a Modern Locomotive

by F. T. VAN SYCKEL

Handy & Harman, New York City

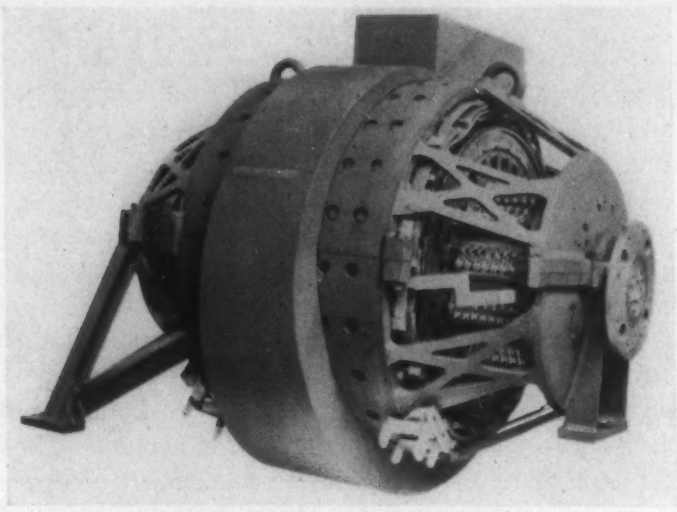
places where the unique qualities of this ancient metal have been put to modern uses. One of the more generally known applications will be evident at night as a powerful headlight throws a brilliant beam, reflected from a pure silver surface, along the track. Hidden inside the electrical control equipment, silver contacts close important electrical circuits as this 5000-h.p. monster gets under way. Even light flashings of silver plating capably protect important electrical connections, to make certain that corrosion does not occur in places where it might prove troublesome.

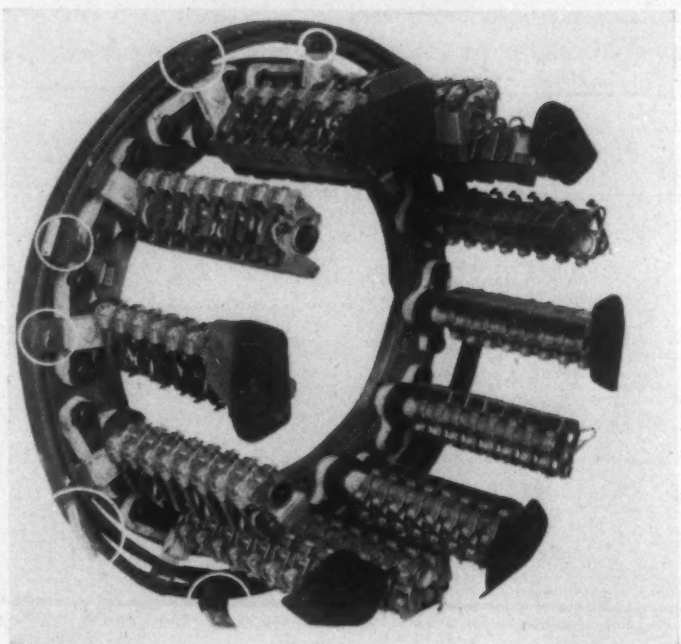
These are a few uses of silver, in a pure or fine state, that are seldom thought of and not often written about in connection with equipment of this kind. But there is another and far wider service that silver provides to industry through the various low temperature silver brazing alloys and silver solders now so widely used.

A Recent Development

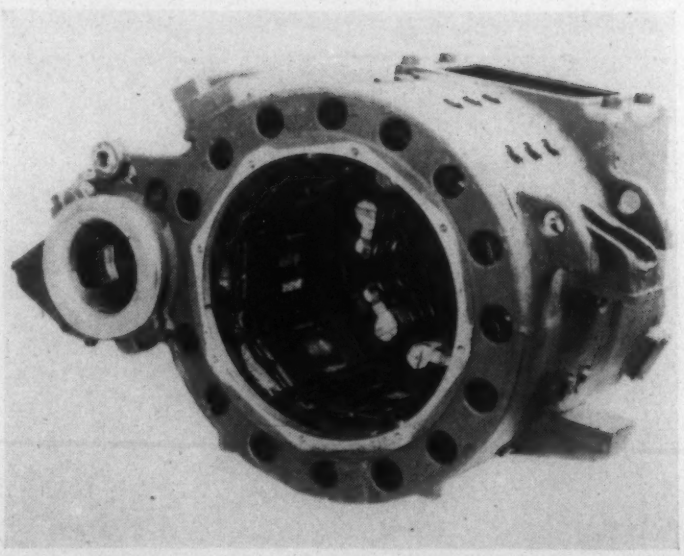
The use of silver alloys for joining metals is not a recent development. It may seem new to some because the uses of alloys of this kind have grown so rapidly in recent years. But modern types of construction and methods of manufacturing have created a demand for better and faster methods of joining metals and alloys and, although welding and brazing with base metals and alloys have been greatly improved, there also has been a remarkable increase in the use of silver alloys for brazing. Research and development of new low temperature alloys which give special advantages in strength, ductility and speed of application have contributed in a big way to this increased use.

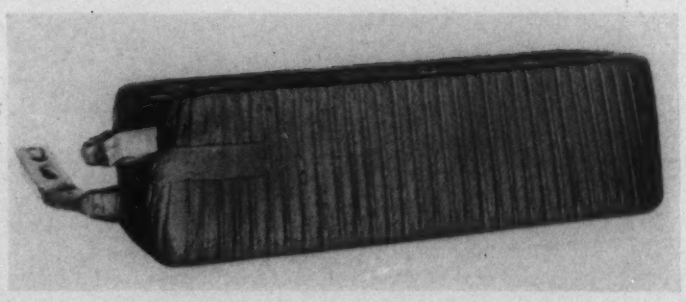
In a limited way, silver brazing alloys have been used on electrical work for many years. The low temperature feature of these more recent alloys, together with improved methods of applying them, has widened this use tremendously, especially where soft solders, rivets and solder, bolts and bolts and solder formerly were used. They also have replaced high temperature brazing alloys in many places to lessen the possibility of damaging the physical properties of the metals joined.





D. C. Tandem Traction Generator: (a) The generator with covers removed; (b) The brush holder collector leads (in circles) are brazed with a low temperature silver alloy.





The D. C. Traction Motors: (a) The motor with armature removed; (b) A field coil showing terminals brazed permanently in place with a silver alloy.

In railroad service, ruggedness and reliability always come first. Coupled with these requirements in electrical equipment is the demand for high efficiency in operation. Low temperature silver brazing alloys fit in with these demands from both the reliability and efficiency angles. They join copper to copper and give the full strength of the copper. They make ductile joints between other metals, steel, stainless steel, brass, Monel metal and other alloys, and these joints withstand vibration, heat of operation and overload, besides giving excellent corrosion resistance. From an electrical standpoint, a properly made joint usually offers as good, or better, conductivity in a circuit as the metals themselves. These alloys do a permanent job for structural or electrical purposes. They are used on pipe lines for lubricating oil, fuel tank heaters, condenser lines and on some steam lines, up to 200 lbs. pressure, for heating and hot water.

In Electrical Circuits

In electrical circuits on the d.c. traction generator there are many uses for silver alloys. Here a low temperature alloy called 'Sil-Fos," composed of 15 per cent silver, 80 per cent copper and 5 per cent phosphorus, is used to join copper leads to the copper brush holder collector rings. In the traction motors, of which there are six to each unit, or 12 on the entire locomotive, all the field coil terminals are brazed with silver alloys.

The automatic control equipment shows further uses. Another silver alloy called "Easy-Flo," flowing at the low temperature of 1175 deg. F. and containing 50 per cent silver, joins stainless steel terminals to resistor wires. Blowout coil contactors are brazed in place with a silver alloy and shunt leaves, located on one side of the generator, are brazed to terminal blocks.

A unique arrangement in the braking system is the use of traction motors as generators to help stop the train. A large water-cooled braking resistor dissipates heat created by the energy generated and, here again, a low temperature silver alloy is used to make certain joints between stainless steel parts.

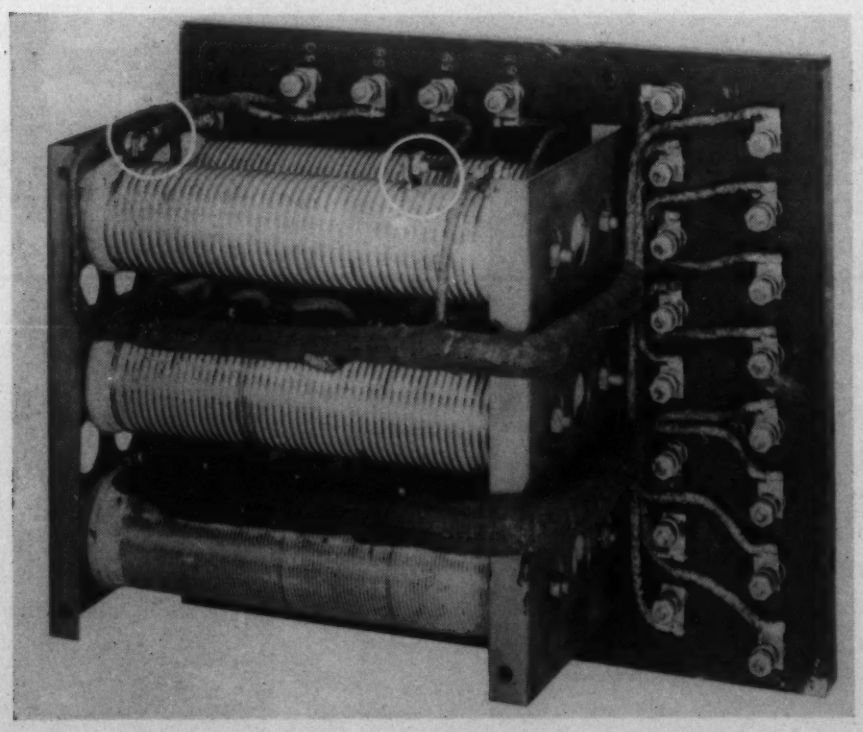
Pipes and Tube Brazed with Silver Alloys

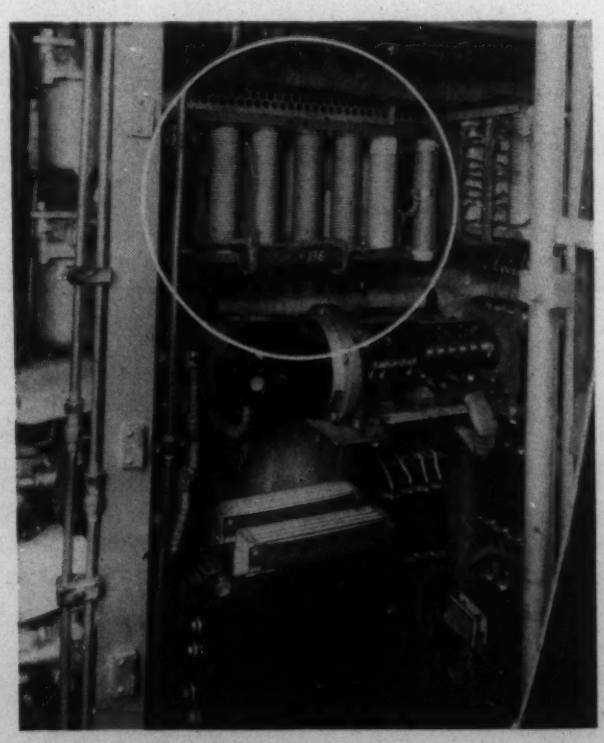
The auxiliary equipment includes a motor generator set which utilizes these alloys on field coil terminals. In the evaporator which takes care of steam for heating the train and hot water, there are a large number of copper tubes brazed with a silver alloy to heavy steel headers. The unit heater for heating the cab has a heating element assembled with the aid of these alloys.

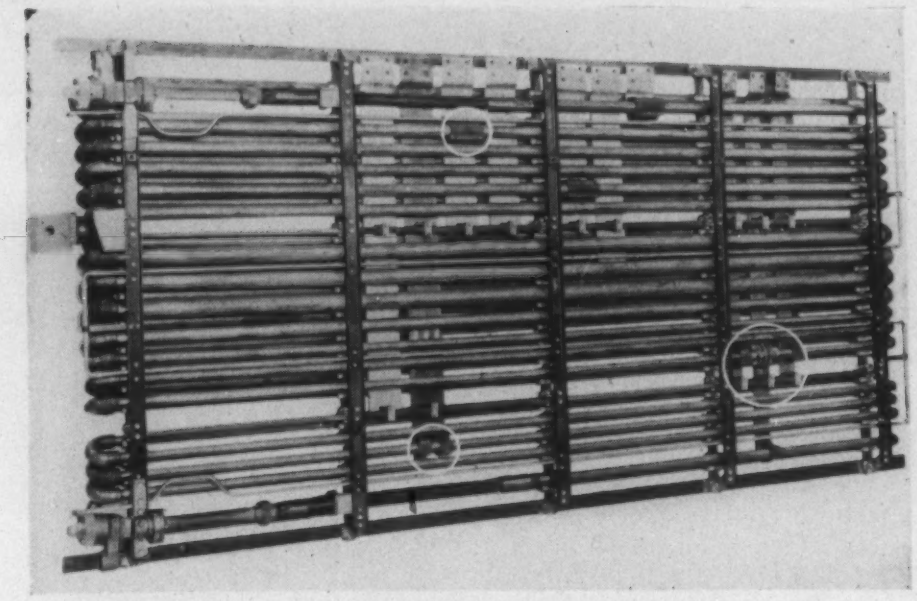
Throughout the locomotive, wherever copper piping lines were assembled, all joints were brazed with silver alloys, except where flared type fittings were used. There are hundreds of these joints and, although out of sight, they serve reliably; a fact which has been responsible for the great increase in the use of this kind of joint, especially where service conditions are severe.

The illustrations give a more complete idea of the kind of service silver brazing alloys render in the construction of this new locomotive.

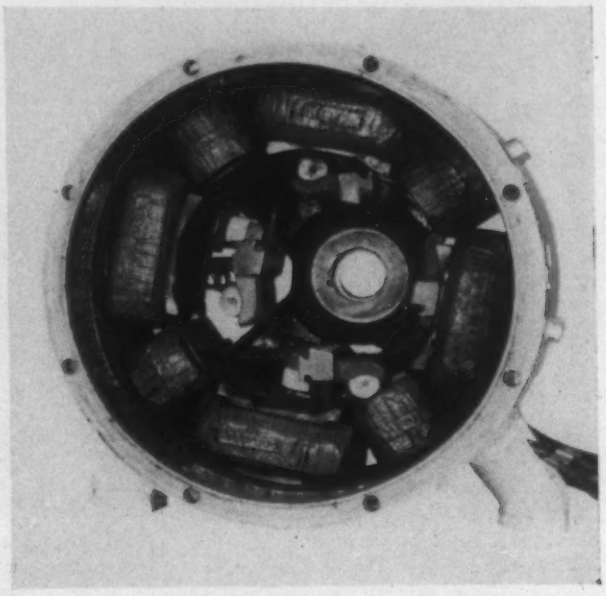
Control Equipment: (a) The 18 and 8 stainless steel terminals on this resistor panel are brazed with a silver alloy to resistor wires; (b) In the auxiliary control compartment blowout coil contractors, resistor terminals and blue stick resistors all rely on silver alloys for permanent connections.



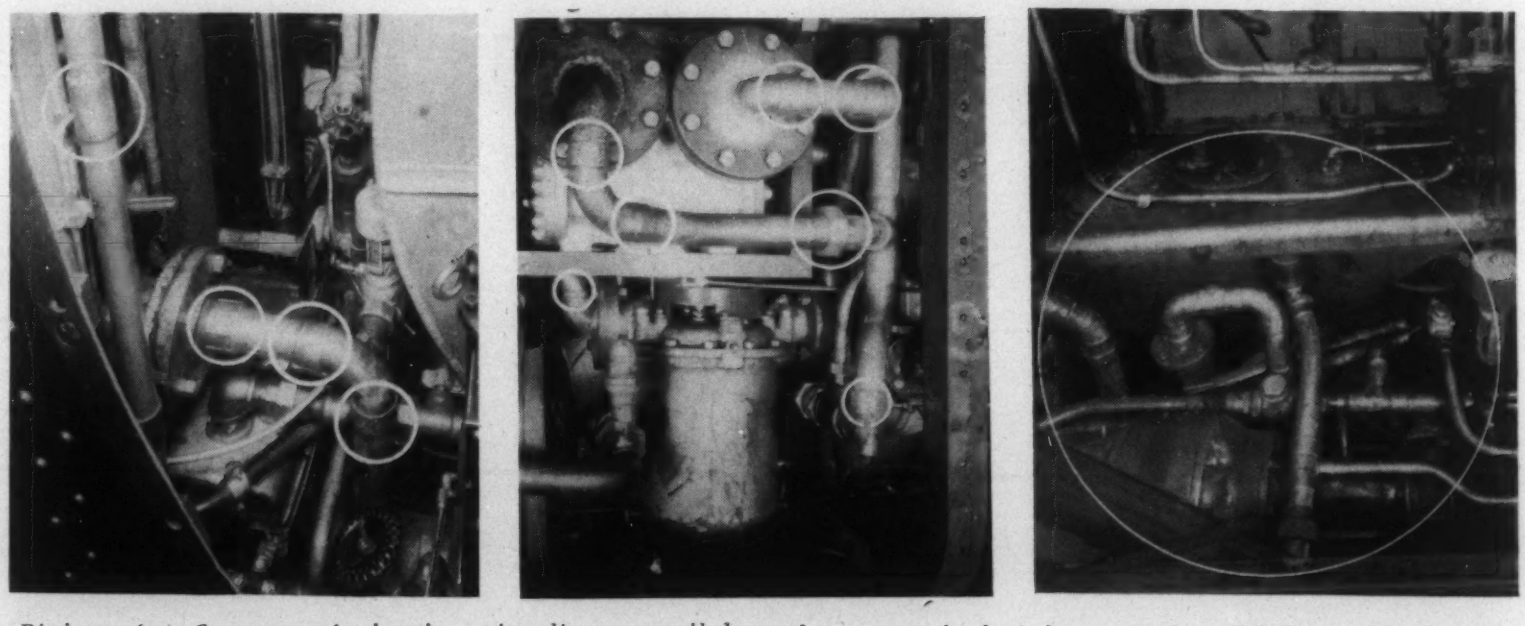




Braking Resistor: The water-cooled braking resistor is made of stainless steel and several joints are brazed with silver alloys to get strength at varying temperatures as well as sound joints that withstand vibration.

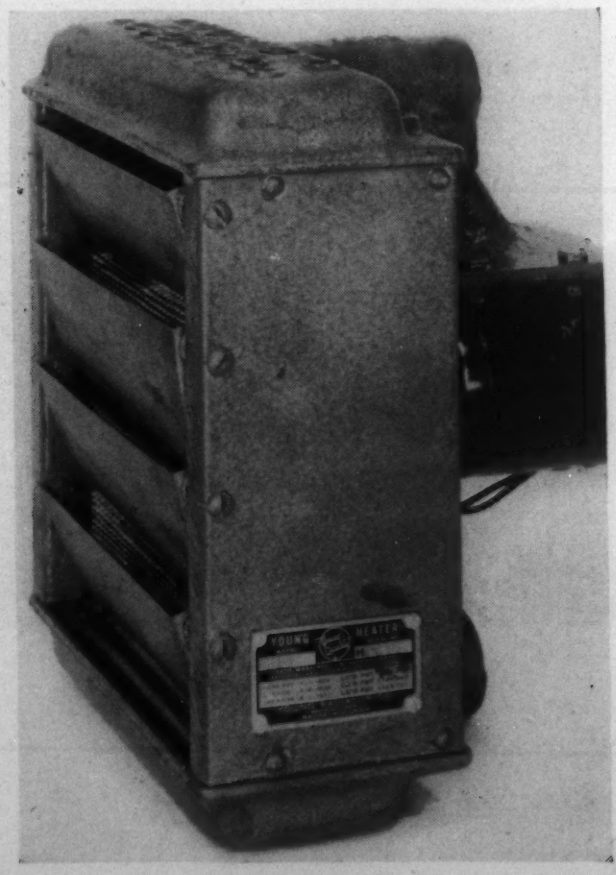


Motor Generator Set: The field coil terminals in the d.c. generator are silver brazed.



Piping: (a) Copper train heating pipe lines are all brazed to assure leak tightness and avoid the need of future repairs; (b) More copper pipe at the end of the boiler is brazed permanently in place with silver alloys; (c) Lubricating oil pipe lines are silver brazed. Sleeve type fittings are joined with one alloy flowing at 1300 deg. F.—unions are joined to pipe with another alloy flowing at 1175 deg. F.

The Evaporator: This evaporator, made by the Foster Wheeler Corp., takes care of steam for heating and hot water. The copper tubes inside are brazed with a low temperature silver alloy to steel ferrules which are welded to the steel header.



Right: The Cab Heater: Headers in this heater, made by the Young Radiator Co., which heats the cab, are joined to tubes with a silver alloy.

Metallurgical observers checking the pouring of a large heat of steel in one of Republic's plants.

Metallurgical Observers in Steel Making

by EDWIN F. CONE

A DEVELOPMENT OF COMPARATIVELY RECENT DATE —within the past 10 to 15 years—has been the use of metallurgical observers in large steel plants. By this is meant an organized body or corps of young men who perform special duties connected with the production of open-hearth, electric and other grades of steel on a large scale. Several of the major steel companies have such groups of men at their various plants.

With the object of getting a general picture of the role which these observers play in a representative organization, the officials of the Republic Steel Corp. were approached. An opportunity was granted the writer to visit three of this organization's steel making plants where metallurgical observers are a factor. Visits were made early this year to the Buffalo, the Youngstown and the Massillon-Canton district plants.

While the practice in the use of these observers is not entirely the same at each plant, the scheme has several features fundamentally alike—a common denominator, so to speak—so that a general and interesting statement is possible. The results are offered in the following paragraphs.

Personnel

Each group of metallurgical observers in each plant consists of from 10 to 20 young men, their ages averaging from 21 to 26 years. Usually they

The temperature, the scaling and other conditions surrounding the steel ingot as it comes from the pit heating furnace in a Republic rolling mill are recorded by observers.

A metallurgical observer checks the temperature of an open-hearth heat of steel at one of the plants of the Republic Steel Co.

are selected from among the graduates of technical schools or colleges—not necessarily metallurgists but technically trained men. There are exceptions to this general statement because high school men are used, and there are local conditions which make it preferable to use some local young men, not technically trained but having ability and character, often recommended by officials. Not infrequently this latter class turns out to be men capable of promotion. Unquestionably the trend, however, is toward technical men in these groups. As the work of these men develops toward more technical work and observations, this is becoming more and more necessary. So much for the background of these observers.

How They Start

These young men, when they start their work, are introduced to their future duties differently in the plants referred to. In one, they are started usually in the testing department of the metallurgical laboratory where they become acquainted with the details of preparing all kinds of tests. The next step is to put them—or at least most of them—in the order department. Here they become acquainted with all the orders of various customers—with the specifications, with the classes of steel to fill each order and with other necessary details. From this point they progress to the metallurgical department where they become versed in a general way with general metallurgical processes and practice.

In some of the plants the prospective observers are placed at once under experienced observers and schooled in the duties for such a time as seems necessary. In other places they may be introduced to their future work by direct contact with melting, heat-treating and rolling operations, or in other departments where they may secure general knowledge of steel-making operations. Ultimately they assume the responsibility of full-fledged metallurgical observers.

The main departments of a large steel plant in which these observers operate are the melting department—open-hearth or electric — and the rolling mills. Some plants use them to a limited extent in other departments. In reality they are an important controlling factor in these operations. A typical example of the relation of these observers to other operating men is the following practice at one plant.

In the Melting Department

Each department of the plant has a department metallurgist. These are ultimately chosen from the group of metallurgical observers. The department metallurgists, such as the open-hearth or the bar mill metallurgist, are under the main or chief mill metallurgist who reports directly to the chief metallurgist of the plant. Each department metallurgist, such as the open-hearth metallurgist, is responsible for the metallurgical practice in his department. In this department, there are rules of standard practice for each heat of different types of steel. It is the duty of the observers, by checking additions, temperatures before and after pouring, slag conditions, lime-silica ratio, ingot molds, and numerous other details, to report on each step. Thus a history of the heat results.

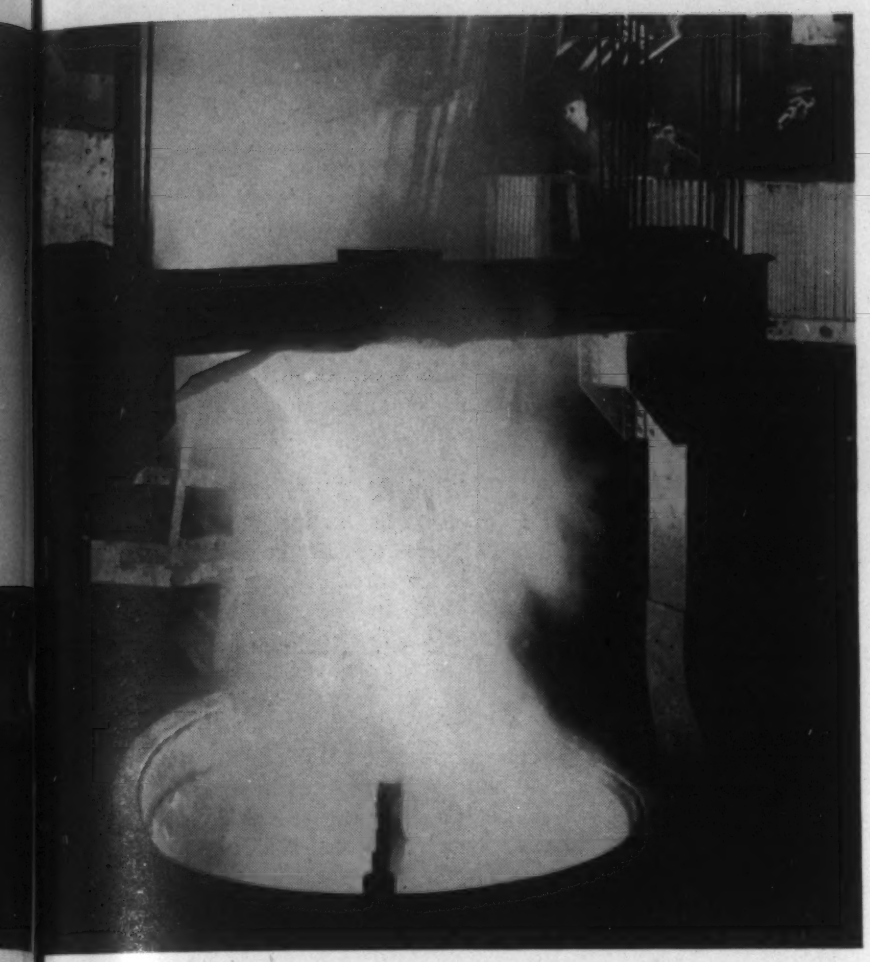
In Rolling Operations

In the rolling mills the duties vary from recording the temperatures of the ingots in the soaking pits and when the ingots are taken out, their surface condition, the temperature and speed of rolling, and so on. In some cases observations of temperatures and other phenomena in the finishing mills are made.

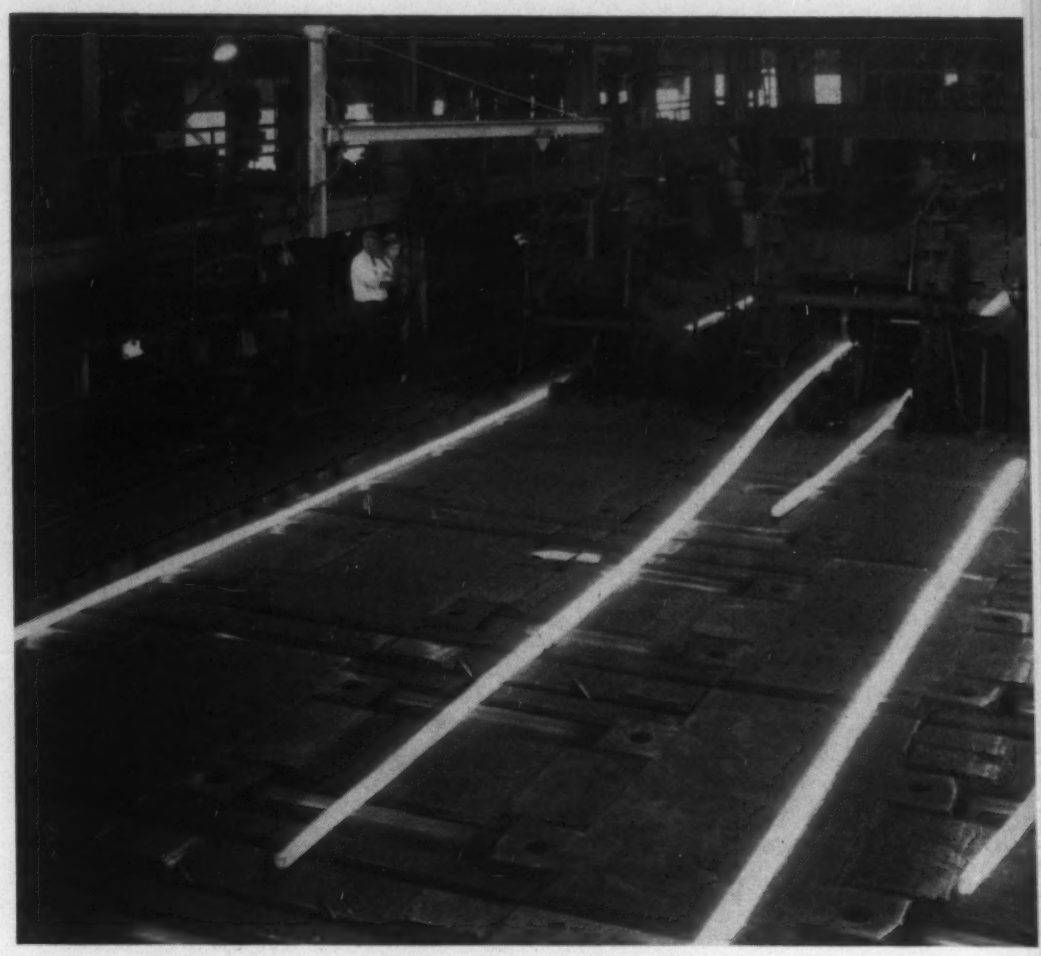
Deviations from mill practice, as promulgated by the chief metallurgist and the metallurgical department, are pointed out and recorded. Because of this, there is a pronounced incentive for the operating men—melters, heaters, rollers—to measure up to the standards. Should there be any falling down by any operator, the records make it possible to locate quite definitely the cause or causes of defects or abnormalities.

An important fact is that these observers are independent of the mill or operating department in that their duty is to report just what they observe,

Tapping a heat of electric steel from a 50-ton furnace and observing the temperature and other characteristics of the metal from one of Republic's batteries of furnaces.



The hot rolling of steel rods is one of the operations which is carefully checked by the corps of metallurgical observers in Republic's rolling mills.



uninfluenced in any manner. Gradually each man, fitted for such work, becomes skilled in the detailed operations of each department.

Solving Special Problems

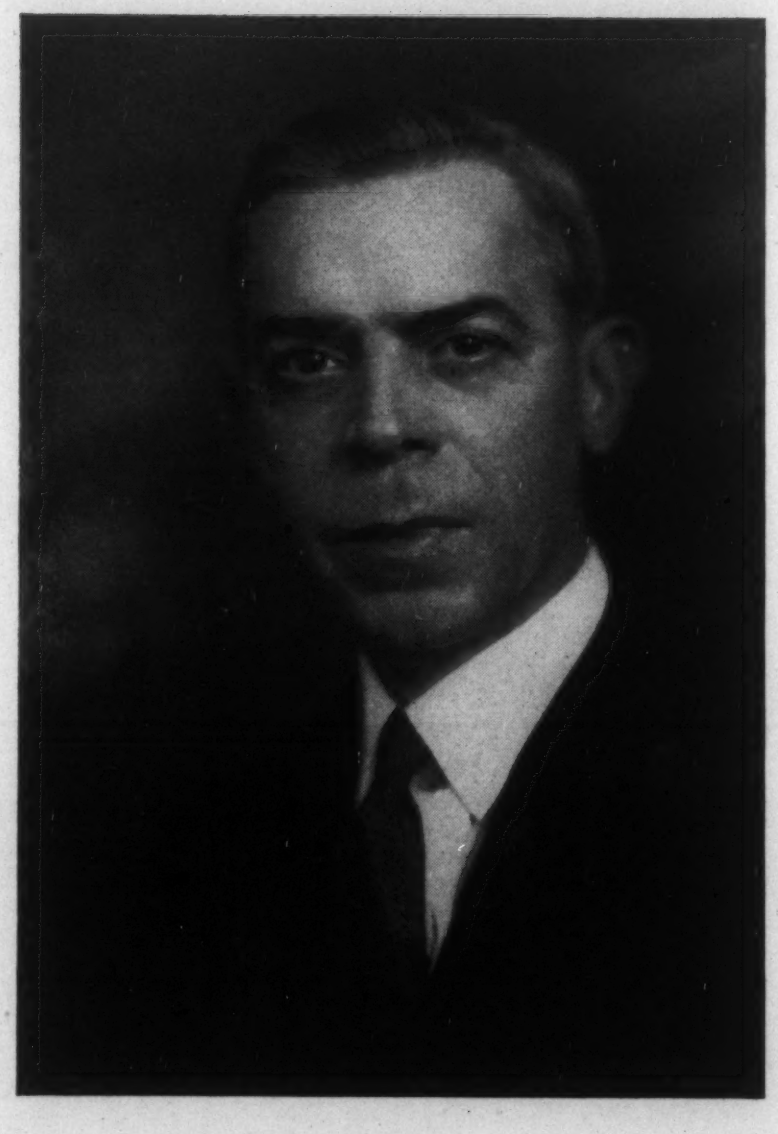
From time to time, aside from the regular routine duties, the observers are assigned the solving of certain problems that arise, involving some special investigation work—for example, the study of tapping temperature and its effect on ingot defects and ingot structure and how these affect the surface and physical properties of the finished steel. Or again, a study may be made of the correlation of the physical structures and appearance of the slag on some special or particular property of the steel, as for instance the freedom of the steel from types of non-metallic inclusions that increase the tendency of the steel to blister in the pickling operation.

In general the picture as outlined in the foregoing paragraphs reflects the fundamentals in the work of the metallurgical observers. At the various plants visited—Buffalo, Youngstown, Massillon-Canton—the practice in the use of these young men varies in certain details. In one they are used merely as observers—they do not have any special problems to solve. In others their relation to their superiors differs in rather unimportant details. Fundamentally their work is largely one of control and its importance cannot be over-emphasized. Undoubtedly the introduction of such a corps of men has been one factor in the gradual improvement of steel in general—an undeniable fact in the last decade or so.

In his Howe Memorial Lecture before the American Institute of Mining and Metallurgical Engineers last February, Charles H. Herty, of the Bethlehem Steel Co., in discussing "Slag Control," made numerous references to the duties and work of the metallurgical observers. It was clearly evident that this corps of men play an important role, not only in slag control but also in metallurgical control in general.

Develop into Key Men

A fact of general and paramount interest is that, in some of the plants visited, from these observers come ultimately some of the key men of the plants' operating force. It should again be stressed that these young men do not have to be metallurgically trained though by far the large majority of them are. Not infrequently a non-technically educated man shows unusual adeptness and skill in certain departments or in one particular department and blossoms out into a valuable man. But by and large, the corps of metallurgical observers, among whom may be found some mechanical or electrical engineers as well as metallurgical engineers, are the fountain source of many of the valuable operating men as the years go by.



AN APPRECIATION OF

Charles A. McCune

DIED OCT. 13, 1940

McCune was a wise councilor, not only in respect to welding, in which he was one of the pioneers, but in many other fields. But the attribute that makes him most missed by his many friends was his unquenchable cheerfulness. Both technically and personally, his passing is a severe loss to METALS AND ALLOYS.—H. W. Gillett

First of all, Charlie was an optimist. To him the bottle was always "half full, thank God," not "already half empty, damn it." Even when only quarter full there was always a shout of welcome from Charlie to share whatever was going around; for generosity was as instinctive and instantaneous as optimism.

I think both of these outstanding traits of his character were a reflection of his great capacity to love. He loved his family, his dog, the squirrels and birds of his vicinity, and in addition his neighbors.

There was no need of the injunction, "Love thy neighbor as thyself." Charlie did this instinctively, with no qualifications. From the sweeper in the shop to the president of the corporation, he cared for them as neighbors and brothers in the sight of the Lord. If he could help them, he did so with no care for himself. He operated a one man employment bureau; from behind the scenes, with never a word said, changes and promotions took place in what appeared to be a perfectly accidental manner.

In addition to taking an extraordinary interest in the professional activities of his friends, he cared even more for their personal happiness and that of their wives and children. In fact his great and loving heart had an almost superhuman capacity for care and affection; very tenderly expressed by Professor Adams in hailing Charlie as the "Mother of the Welding Society." That truly was his feeling toward the welding fraternity, and especially the American Welding Society.

Perhaps the Welding Society would be strong and capable even as are other technical groups, if Charlie had not been in that field, but it seems to me that there is a family feeling among the welders due to the close relationship among the extremely able group of founders and old timers who have devoted many years of thought to the good of their industry.

Among this small inner circle Charlie has been by turns a modest and retiring tower of strength, a skillful supplier of oil to hot bearings in tight places, a willing conscript in doing the dirty work of financial management, constant in committee attendance, and always ready, like Aaron, to hold up the hands of his leader Moses.

After working hours Charlie bloomed again in the friendly, impromptu meetings about the table bearing the flowing bowl and dish of potato chips. Business rivals who swore that their neighbor had hoofs, horns and a tail, joined his group and discovered that after all there was much good among the worst of their competitors, and maybe, enough business to go around.

In an inobtrusive way Charlie was a perfectionist. He did his best in every little hidden detail, and by precept and example, by his belief in the ability and honesty of others, he led them so to live that they took an honest pride in their accomplishments. He so delighted in his friends' success that they tried almost unconsciously to earn his approbation. Sloppy work, carelessness, and above all, meanness and petty jealousy were so repugnant to his nature that his scorn of such behavior made his influence felt in all the extraordinary range of his acquaintance.

Charlie is gone from among us, but in honor to his memory may we so live that at all times his spirit would rejoice in our company.—A. V. de Forest

Bearing Metals From the Point of View of Strategic Materials

by H. W. Gillett, H. W. Russell and R. W. Dayton
Battelle Memorial Institute, Columbus, Ohio

THERE ARE GRADATIONS in composition and properties in each group of the common bearing metal alloys. Tin base babbitt may range from 92 Sn, 4 Sb, 4 Cu, with about 20 Brinell at room temperature, to 79 Sn, 12 Sb, 7 Cu or 80 Sn, 10 Sb, 10 Cu, with about 29 Brinell. Lead base babbitts range from 90 Pb, 10 Sb with 14.5 Brinell to 75 Pb, 15 Sb, 10 Sn with 22.5 Brinell, or to one of double the tin content, the same antimony and 1½ Cu, with 21 Brinell.

The alkali-hardened lead alloys vary considerably in composition, and range in hardness from 20 to 35. Cadmium base alloys contain either a little copper and silver, or a little nickel, ranging from 30 to 40 Brinell. Silver and high-silver, low-lead alloys run about 25 Brinell.

In the bearing bronzes there are all gradations from leadless 81 Cu, 19 Sn, 125 Brinell, to 88 Cu, 10 Sn, 2 Zn, and from 85 Cu, 5 Sn, 5 Zn, 5 Pb, 55 Brinell to 70 Cu, 1 Sn, 29 Pb, 35 Brinell, while a straight 65 Cu, 35 Pb has around 20 Brinell.

In all these classes minor additions may be made. A little lead may be permitted in tin-base babbitt, though discussion rages as to its harmfulness, and small additions of cadmium, tellurium, etc. may be made for one purpose or another. Various small additions of other elements to the lead-base babbitts have been suggested, and some intermediate babbitts are made high in both lead and tin. Bearing bronzes often have small additions of nickel, and the tinless Cu-Pb alloy may carry about 1 per cent Ni or Ag.

In the general consideration of properties, all these minor variations cannot be taken into account, since data are lacking for many of the slightly modified alloys. Nor is it necessary to consider all the variations in composition when appraising behavior of alloy types, since the base metal from which the alloy is made exerts the ruling influence upon many of the physical properties; variation in kind and amount of alloying elements chosen affects the behavior only in minor degree. That minor change may often be in the direction desired, and be well worth having, but it is seldom sufficient to move the alloy out of the group in which it is naturally classified. However, there is so large a difference between the common lead-base babbitts and the alkali-hardened leads as to force their separation into two distinct groups.

It will suffice to consider the soft and the hard tin-base, the soft and the hard lead-base babbitts, the alkali-hardened leads, lumped more or less as a class, the cadmium-base alloys, lumped as another class, Cu-Pb without tin and with a little tin, and silver, as alloys for lined bearings.

The straight bronzes and leaded bronzes used as un-lined bushings do not need very much consideration from the strategic point of view, for reasons brought out in the previous installment. It is the replaceability of tin-base babbitt that deserves most attention.

Tin-base babbitt has many virtues. It works against soft shafts, with little tendency toward scoring, it allows low clearance, which is an aid to effective lubrication, it is high in embeddability and conformability, has a low elastic modulus, bonds reasonably well to steel or bronze, is not corroded by most oils at its operating temperature, and it is properly wetted by the "oiliness constituents" of lubricants. Its thermal

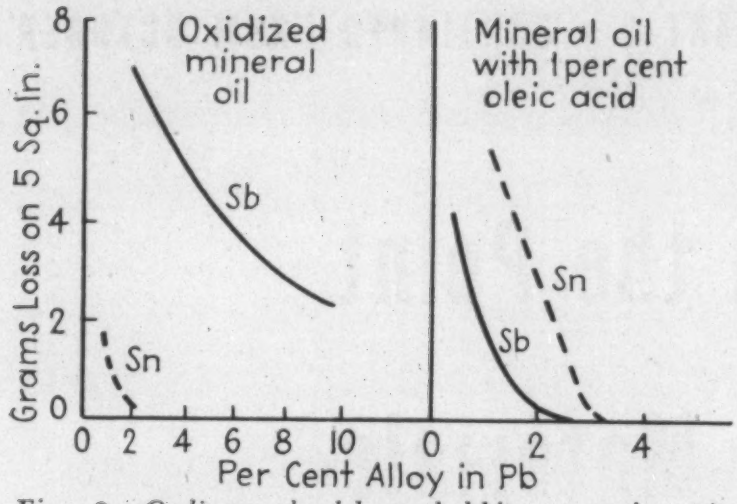


Fig. 9—Ordinary lead-base babbitts, carrying tin and/or antimony, are much more resistant to corrosion in normal lubricants than pure lead. Underwood[36]

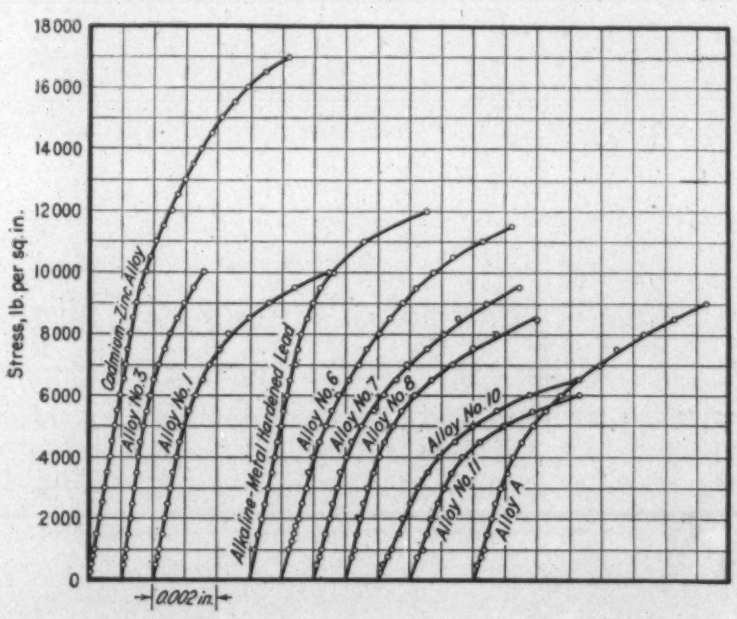


Fig. 10—Stress-strain relation in compression tests at 20 deg. C. (68 deg. F.) of white-metal bearing alloys.

coefficient of expansion is intermediate among bearing metals, its thermal conductivity is also intermediate. Its only major drawback is that tin, the base, was born with a low melting point and the strength falls off markedly as the melting point is approached. It is the base line for comparison of other babbitts.

Clearance and Thermal Expansion

It is considered[36-45] that either tin-base or ordinary lead-base babbitts, in the thicknesses ordinarily used, operate satisfactorily with a clearance of 0.001 to 0.0015 in. in small bearings, or in large bearings 0.001 to 0.0015 times the journal diameter, while bronze and copper-lead require about twice that clearance. Lay[46], however, gives 0.001 to 0.0015 times the journal diameter for steel backed Cu-Pb alloys operating against hard shafts [350 Brinell against straight Cu-Pb (with 20-30% Pb) of 28 to 35 Brinell, 500 Brinell against alloys of similar Pb content but hardened, by up to 2% of Sn, Ni or Mn, to 38-45 Brinell]. Practice differs with the cadmium-base bearings. Swigert and Underwood[37] say they take the same clearance as tin-base, while Willi[43] considers that a little greater clearance should be allowed, as do Ricardo and Pitchford[47].

The alkali-hardened leads are so little used outside of railway service that there is not much background for definite statements on the necessary clearance. Kühnel[40] and other authorities give the clearance for aluminum-base alloys as of the same order as that for leaded bronze, and it is quite commonly stated that this is due to their high coefficient of expansion. While it might be expected that the clearance would depend on the thermal coefficient of expansion, this does not seem to be the case.

Thermal Coefficients of Expansion

Measuring the coefficients in deg. C. x 10^{-6} over the operating temperature range for bearings, the coefficients of expansion, rounded off, are [40, 48] of the following order:

Alkali-hardened Pb	33–34
Cd	32
Zn	30
Cd-base babbitt	29
Pb	28
Mg	26
Al	25
Al-bearing alloys	22–25
Sn-base babbitts	22–24
Pb-base babbitts	24–28
Cu-Pb (77 Cu, 23 Pb)	24–25
Cu-Pb (60 Cu, 40 Pb)	19–22
Ag	20
80-10-10 bronze	18
85-5-5-5	18
Cu	17
Steel	12

Evidently the clearance required is *not* determined by the thermal expansion. It would appear that hardness at operating temperature has a greater influence, soft alloys permitting lowest clearance.

Thermal Conductivity and Modulus of Elasticity

The approximate thermal conductivity at 150 deg. C. (300° F.) of some bearing metals, as given by Kühnel[40], in KCal per m°C. hr. follows:

Pure Ag	360 (approximate values—
Pure Cu	325 Smithsonian tables.)
70 Cu, 30 Pb	115
Pure Cd	80
Cd-base babbitt	70
Bronze	50
Sn-base babbitt (soft)	40
Pure Pb	25
Pb-base babbitt	20
Alkali-hardened Pb	15

The thermal conductivity of a bearing assembly is not very greatly governed by that of the bearing lining, but that of the lining has something to do with

the avoidance of hot spots on the lining surface. From this point of view the lead alloys are at a disadvantage.

The modulus of elasticity at room temperature, in millions of lbs. per sq. in. for various metals and alloys, rounds off to:

Steel	30	Cd-base babbitt	9
Cast iron	15–20	70 Cu, 5 Sn, 25 Pb	7
Cu	14–16	Sn-base babbitt	7½
Zn	12½	Sn	6½–7½
Au	11½	Mg	6¼
80 Cu, 10 Sn, 10 Pb	10½	Pb-base babbitt	4½
Ag	10¼	Alkali-hardened Pb	3¾
Al	10	Pb	2½
Cd	10		

Cuthbertson[49] gives some data on the decrease in modulus at elevated temperature, from which we take the following:

Material						*Modulus* Room Temperature	*Modulus* 300 deg. F.
Sn						6.4	3.6
	Sn	Cu	Sb	Pb	Cd		
	85.5	4.2	9.9	0.3	...	7.7	4
Sn-base babbitts	92.3	3.5	3.8	0.3	...	7.7	4
	92.5	3.5	3.5	...	1	7.5	3.2
Pb-babbitts	80 Pb		15 Sb	5 Sn	...	4.4	2.7
Alkali-hardened	Pb					3.75	2.7–2.0

No data are available on the modulus of cadmium babbitts at elevated temperature. It would be expected to decrease with temperature less rapidly than in the cases of tin-base and lead-base babbitts. The moduli of copper-lead, silver and bearing bronzes would probably not fall off very much at 300 deg. F. According to Addicks[50] that of silver falls only to about 9,000,000 at 500 deg. F. If low moduli are useful, the lead- and the tin-base alloys have an advantage.

Seizure Resistance

Seizure resistance can be experimentally determined in terms of pressure required for seizure, under given conditions of testing, but the nature and finish of the shaft must be specified, and the bearing lining must be thin enough so that the lining does not squash out before the seizure pressure is reached. With ordinary thicknesses of tin-base or ordinary lead-base babbitts, the lining will fail by squashing before seizure can be produced.

According to Underwood[36, 37], Al, Mg, Cu, and Zn tend to seize to and score the shaft, while Sn, Pb, Cd, and Ag are much less likely to seize and score.

The element most used to minimize seizure and scoring is lead. As large amounts as can be incorporated with reasonable uniformity are desired in the Cu-Pb alloys. The pools of lead may provide some degree of embeddability, and in straight Cu-Pb, the whole alloy has some slight degree of conformability, since the cast copper matrix has a low proportional limit. Indeed, when the bearings have to stand high pressure, the straight Cu-Pb may be unsatisfactory because of squashing out, so that in actual severe duty service the matrix is generally strengthened by adding around 1 per cent of Ni or Ag, or, more commonly 1 to 2 per cent Sn. As the tin content becomes high enough to stiffen the matrix materially the ability of the lead smeared over the bronze surface to cover that surface well and prevent seizure, diminishes, so the leaded bronzes become more and more prone to seize and score as the tin increases and the lead decreases. Hard shafts are definitely called for.

Pure silver recently has been used to stand high pressures and avoid scoring of the shaft in services in which a low tin, high lead bronze (called copper-lead) was previously used. The performance of pure silver has been good, though as Dayton[51] points out, it is not entirely resistant to seizure. Its seizure resistance can be greatly improved, about doubled, by addition of 2 to 3 per cent Pb.

The seizure resistance of the cadmium-base babbitts is excellent.

Ability to Run-In and Bondability

The ability to run-in, as described in Section I [September, page 274] from the work of McKee, appears to be pretty much on the order of the room temperature hardness, the hard bronzes requiring extremely perfect fitting and preparation of surfaces of both shaft and bearing, while with the soft babbitts the running surfaces readily wear in to a proper fit and finish.

The ability to bond themselves to the bearing back is high in the tin alloys and reasonably good in the lead-base babbitts that carry tin. The alkali-hardened leads free from tin, like Bahnmetall, are very deficient in bondability, and Satco carries about 2 per cent Sn, partly to remedy this deficiency.

Smart[52] and Evans and Harrison[53] remark that Cd-Ag-Cu does not bond well to steel while Cd-Ni does, so a "tinning" coat of Cd-Ni is applied first when the Cd-Ag-Cu alloy is used.

Dayton discusses the difficulties of direct coating

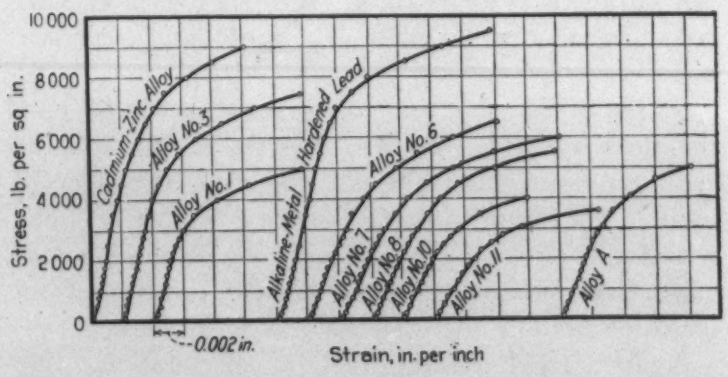


Fig. 11—Stress-strain relation in compression tests at 100 deg. C. (212 deg. F.) of white-metal bearing alloys.

of steel with molten Ag-Pb alloy, which are avoided by electroplating. It is understood that certain non-ferrous backing materials can be coated with the molten alloy, however.

Coating a steel back with the high lead Cu-Pb or Cu-Sn-Pb alloy is a difficult matter because of the high temperature necessary. This constitutes a serious drawback to the more general use of these alloys.

Corrodibility

A drawback to the use of the Cu-Pb or Cu(Sn)Pb alloys, and to that of the cadmium-base alloys lies in the corrodibility of lead and cadmium by the oxidation products produced in many present day oils at temperatures of 250 deg. F. or above. Tin-base alloys are not so readily corroded, practically not at all at temperatures at which it is feasible to use them. Except for corrosion, the Cu-Pb and cadmium-base alloys would be immediate choices for the range of temperatures just above those at which the tin-base babbitt can be used.

Ordinary lead-base babbitts, carrying tin and/or antimony, are much more resistant to corrosion in normal lubricants than pure lead. See Fig. 9. These additions cannot well be made to the lead pools in Cu-Pb because tin and antimony go chiefly into the copper, hardening the matrix, and not supplying enough to the lead to alter its corrodibility. Underwood[37] classes silver as entirely corrosion resistant. The cast, or the plated and annealed high silver, low lead alloys, according to Dayton[51], are corrosion resistant. The oil producers have been actively engaged in compounding oils with corrosion-inhibiting additions to prevent attack on Cu-Pb or cadmium-base alloys, literally hundreds of such additions having been patented. The difficulty with that solution in automotive practice is that the oil lubricates the cylinders and piston rings as well as the bearings, and the problems of ring-sticking and "varnish" formation have also to be met, so that special oils that might serve nicely to permit the use of Cu-Pb or cadmium-base bearings, may not be admissible for other reasons. But the worst difficulty is that unless it is impossible for the motorist to buy a corrosive oil at any filling station whatever, the bearings may have sometime to operate with a non-inhibited, corrosive oil.

If the oil is made non-corrosive, or if the oil temperatures are kept down so that the Cu-Pb and the cadmium-base alloys are not corroded, they can be used. The Ford floating bushing, formerly lined with Cu (1% Ni) Pb, now with one or another cadmium-base babbitt, operates without difficulty from corrosion because the temperatures are not excessive.

Smart[52] tried another method of solution. He plated a thin film of indium over Cd-Ag-Cu babbitt and diffused it into the babbitt by heating, to produce an indium content of 0.20 to 0.50 per cent. This was found to prevent corrosion, and appears to be equally effective on Cu-Pb. However, the method does not seem to have been put into use on a commercial production scale[54]. (Current advertising of the White truck states that its Cu-Pb engine bearings are indium treated.) Certain patents suggest adding 0.1 to 1 per cent Sb to Cd-Ag for corrosion resistance. Corrosion has been a serious drawback in the alkali-hardened lead babbitts. Shoemaker[55] (See also[56]) considers that the addition of a little tin avoids this trouble.

It is usually considered that tin-base babbitt is resistant to corrosion in any oil likely to be encountered commercially, and that the Cu-Pb and the cadmium-base alloys are much worse in corrosive oils. However, McDonald[57] showed that this all depends on the oil and the temperature. McDonald compared tin-base babbitt and Cd-Ag babbitt in four commercial oils at temperatures from 210 to 360 deg. F. At 210 deg. none of the oils appreciably attacked either bearing. At 240 deg. two of the oils attacked Cd-Ag, one slightly, one severely, but none had much effect on tin-base. At 270 to 300 deg. one oil showed a severe attack on Cd-Ag but did not attack the tin

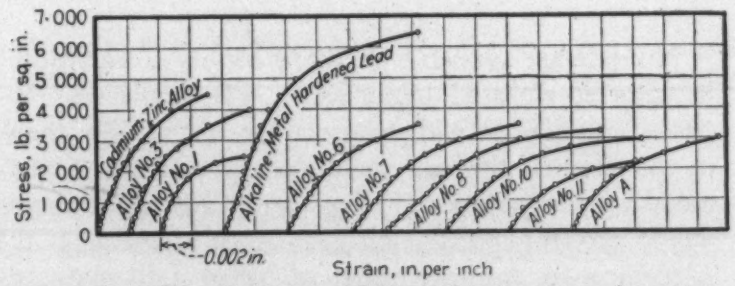


Fig. 12—Stress-strain relation in compression tests at 150 deg. C. (300 deg. F.) of white-metal bearing alloys.

babbitt. Another attacked the tin-base more severely than it did Cd-Ag. A third attacked tin babbitt quite strongly, but only attacked the Cd-Ag slightly; a fourth did not harm either one very much. At 330 and 360 deg. all three oils showed serious attack upon both the tin base and the Cd-Ag, while the fourth corroded tin-base severely, but not Cd-Ag. Active chemical attack on the bearing, of course, alters the oil itself, so an engine needs to have its temperature kept down for the benefit of the oil and if the temperature is sufficiently kept down, the tin-base and lead-base babbitts are not at such a disadvantage in strength as they are at very high temperatures. Larson[58] discussed the use of Cu-Pb at considerable length, coming to the conclusion that if crankcase temperatures could be kept below 170 deg. F., babbitt was decidedly superior.

Fatigue Resistance

The cracking of the lining of a lined bearing in

service may be due to poor bonding, or to fatigue failure of the lining.

Underwood[36, 37] appraises fatigue strength as usually the most important property of a bearing. He finds that when the linings are well supported and used very thin, tin-base, ordinary lead-base, and alkali-hardened lead all have about the same fatigue resistance. Macnaughtan[59] claims somewhat improved fatigue resistance on the basis of tests at 300 deg. F. in tin-base babbitt from the addition of 1 per cent Cd. But Evans and Harrison[43] say that trials of tin-base babbitts carrying cadmium in modern aircraft engines have been disappointing. The addition of 3 to 4 per cent Ag instead of cadmium, however, reduced fatigue cracking. Claims, not substantiated by published data, have been made for improvement in fatigue resistance by the addition of a little tellurium to tin base babbitts.

Cadmium-base babbitt, says Underwood[36, 37] has about three times the life of the three alloys mentioned above, copper-lead has about five times the life, and silver, "will stand up under operating conditions which no other bearing will survive for one-tenth the time." He illustrates a silver-lined steel-backed bearing in which the steel back failed by cracking without cracking the silver lining. Zink and Ryder (see ref. 51) also indicate the vastly greater fatigue resistance of silver over Cu-Pb. Swigert[42] also notes the high resistance of silver to fatigue. Thus, as a first approximation, the fatigue lives stand pretty much in the order of the strength and hardness of the materials at 300 deg. F.

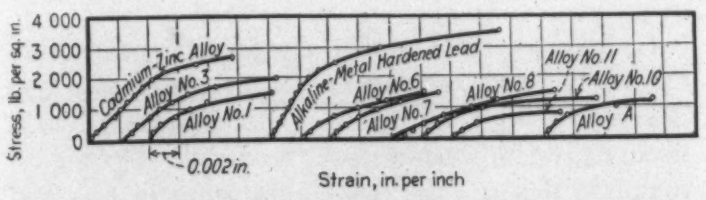


Fig. 13—Stress-strain relation in compression tests at 200 deg. C. (390 deg. F.) of white-metal bearing alloys.

Creep Resistance

The load-carrying ability of a babbitt, in a short-time test, may not accurately represent its ability to withstand long continued loading, as is evident from creep data for lead and lead alloy cable sheathing. It is recognized for alloys in general, that creep properties are not accurately determinable by any short-time test.

Creep data on babbitts are very scarce. Swartz and Phillips[60] conclude that the long-time load-carrying ability of a 6¼ Sb, 5¼ Cu, Sn-base babbitt is about 200 lbs. per sq. in., that of a 98.65, Cd 1.35 Ni babbitt about 2,000 lbs. per sq. in., both at room temperature.

Macnaughtan[59], however, puts the long-time load-carrying ability of a 7 Sb, 3½ Cu, tin-base babbitt at 190 lbs. per sq. in., at 300 deg. F. Both sets of data are for tensile creep on massive specimens, while compressive creep on thin linings is what is actually concerned. What has been termed an evaluation of "flow," but what is more accurately an approach to an appraisal of the work-hardening behavior in compression, is discussed by Harrison and Wood[61]. They determine what is practically the Meyer index in that the log of the diameter of a 10 mm. Brinell ball impression made with a 500 Kg. load at room temperature for periods of 30, 100, 200, 300, and 600 seconds is plotted against the log of time. The plot approximates a straight line, the slope of which is, in the opinion of Harrison and Wood, an index of conformability. They point out that different alloys of the same (30 sec.) hardness, differ in the slope of the line. They find that a lead bronze (composition not stated) gives a slope of less than 0.01, tin-base babbits 0.02-0.03; Cd-Ni 0.023; ordinary-lead base babbitts over 0.04; and the intermediate alloy, 50 Pb, 40 Sn, 10 Sb, 0.075. They consider that a slope of 0.015-0.025 is the optimum, smaller values indicating too little conformability, larger ones too much tendency to squash.

Such tests doubtless evaluate the workhardenability of the alloy at room temperature but 600 second tests cannot be rated as "creep" or "flow" tests, and they would have to be made at actual operating temperatures to indicate anything about the behavior at those temperatures. Nevertheless, the similarity of behavior of tin-base and cadmium-base babbitts, contrasted with that of the lead-base, is of interest.

Damping and Properties at Elevated Temperatures

It is alleged[45] that the high damping capacity of leaded Cu-Ni-Sn bronzes of 50 to 70 Brinell, used as thick bearing backs for white metal linings in Diesel engine bearings, may have played a part in the improved fatigue resistance shown by such bearings. However, it is also stated that Cu-Pb on a steel back is still better. What effect variations in damping capacity may have on bearing performance is not at all clear.

Whether the temperature limitations of tin-base and lead-base babbitts are primarily due to their squashing out, as they do when used in relatively thick linings, or to fatigue failure, the static properties of the various bearing metals at elevated temperatures are of interest. Apparently an operating temperature of 300 deg. F. is at the upper limit that will permit a fairly wide choice of materials. Properties at that temperature seem to give a good bird's-eye comparison of the different alloys.

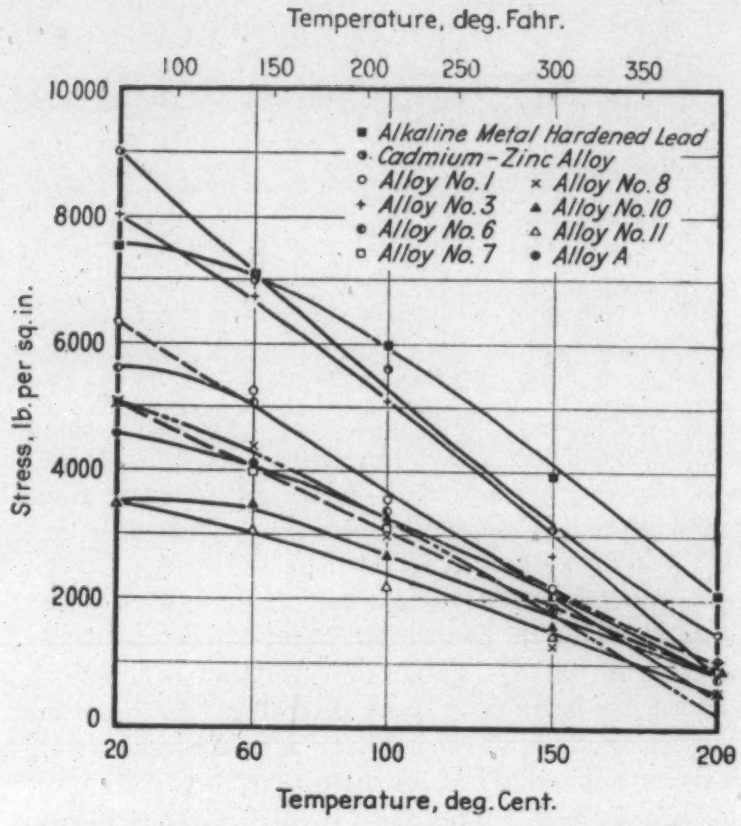


Fig. 14—Relation of compression stress, producing 0.3 per cent deformation, to temperature of test.

Anticipating some of the more detailed data on high temperature strength, the various alloys group themselves as follows:

Hardness at 300 deg. F.

Below 5	Pb-Sb without Sn
6-10	Ordinary Pb- and Sn-base babbitts
11-17	Alk-hard Pb; Cd-Cu-Ag; Cd-Ni
21-23	Cu-Pb, no Sn
25-30	Cu, high Pb, 1% Sn; Ag; Ag-Pb
35-55	Cu, high Pb, 2 to 6% Sn
55-75	Cu, medium Pb, 10% Sn, (20 to 5% Pb)
60-125	Non-leaded bronzes

There are some data on tensile properties of bearing metals at elevated temperatures, but since loading is always in compression, compression data are of more interest. The best bird's-eye view of the elevated temperature properties of tin-base and lead-base babbitts is given by Herschman and Basil[62]. They tested two standard tin-base and six standard lead-base babbitts. An alkali-hardened lead of an older type was included, but the data should not be considered representative either of the German alloy "Bahnmetall" or the American alloy "Satco," the compositions of which are decidedly different from the one used. The data appear to be reasonably representative of Bahnmetall, but are not accurate for the modern type of Satco. They included also specimens of the Cd-Zn eutectic, without antimony, which is present in the bearing alloy based on that eutectic, so that the results on these specimens are not characteristic cf that alloy, still less of the Cd-Ag-Cu and Cd-Ni babbitts. Hence, the reader should disregard the curves in the figures for Herschman and Basil's alloys Cd-Zn and Alk-hard Pb. Their alloy A, represents a foreign trade-named alloy, little used in this country.

The composition of Herschman and Basil's babbitts are given in the table.

TABLE OF COMPOSITIONS OF WHITE-METAL BEARING ALLOYS

Alloy	Lead per cent	Tin per cent	Antimony per cent	Copper per cent	Cadmium per cent	Zinc per cent	Other constituents per cent
No. 1	...	90.9	4.6	4.5	..	..	..
No. 3	...	83.8	8.1	8.1	..	..	..
No. 6	62.3	20.8	15.5	1.4	..	..	..
No. 7	78.8	8.4	12.8	..	..	..	..
No. 8	79.7	5.0	15.3	..	..	..	..
No. 10	87.0	1.2	11.8	..	..	..	..
No. 11	88.1	..	11.9	..	..	..	..
Alkaline-earth metal hardened lead	96.93	0.18	...	0.1	..	..	Hg 0.33, Ba 1.70, Ca 0.70
Cadmium-zinc[a]	...	...	..	..	82	18	..
A	80.6	3.8	13.5	1.0	0.2	..	Ni 0.2, As 0.6

[a] Nominal composition.

The tests were made on massive specimens. It should be recalled that very thin linings on hard backs will not have the same properties as the massive specimens.

Compression stress-strain diagrams are shown in Fig. 10 at room temperature, at 212, 300, and 390 deg. F. in Figs. 11 to 13. The decrease in yield strength and in modulus will be noted. On the assumption that 0.3 per cent deformation in compression represents the compressive yield strength Fig. 14 shows the relative strengths over the range of temperatures.

A sort of compressive stress strain diagram is also obtained from repeated pounding tests, and these also serve to show the rate of work hardening. Such data are given in Fig. 15, and show that the lead-base alloys work harden more readily at elevated temperatures than the tin-base do. Izod notched bar impact data are shown in Fig. 16.

Amsler wear test data were obtained at room temperature, using kerosene, in the hope of simulating starved conditions of lubrication. The data are shown in Fig. 17. The Brinell hardness is shown in Fig. 18. It will be noted that compressive yield strength and resistance to pounding fall quite uniformly in the same order as the Brinell hardness; also, that the Brinell hardness at 300 deg. F. sorts the alloys pretty well into the order of their known load-carrying ability in service, even though only a small range, $6\frac{1}{2}$ to $8\frac{1}{2}$ Brinell, appears in the hardness of the most important commercial tin- and lead-base babbitts.

Intermediate Alloys

We may compare with Herschman and Basil's No. 6 some German alloys mentioned by Kühnel[40] and

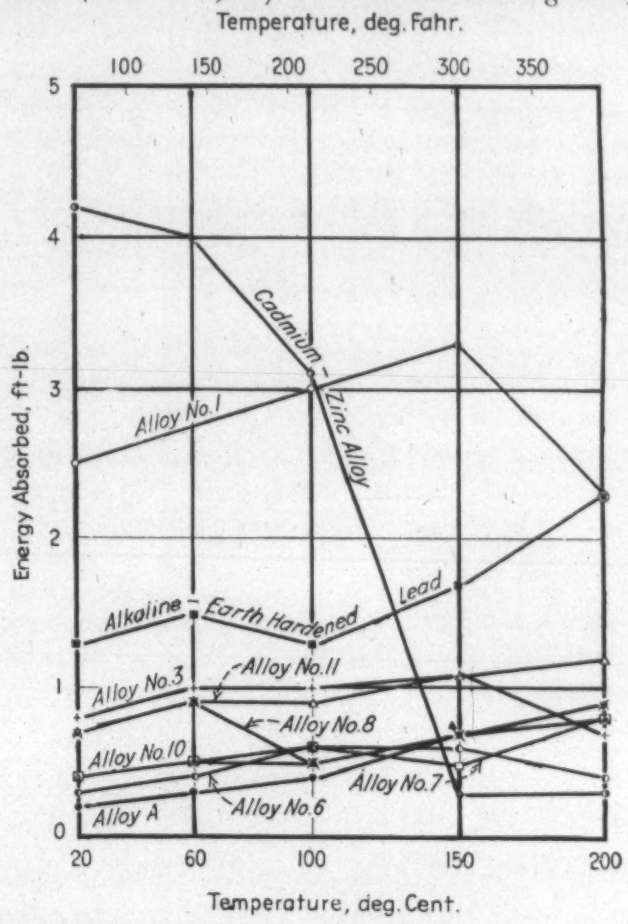
by the Werkstoff-Handbuch[63]. The high tin in W. M. 42 does not improve the hot hardness over that of No. 6.

Ref.		Composition Pb	Sn	Sb	Cu	Brinell Room	212 deg. F.	300 deg. F.
61	No. 6	62½	21	15½	1½	20	11½	8
40		41	42	14	3	18–19	10–11	6
63	W.M.42	41	42	14	3	22½	5	less than 4
63	W.M.50	33	50	14	3	23½	5	..

The hardness data given by Hertel and Demmer[64] and shown below for a group of alloys with what might be termed a solder base, equal amounts of lead and tin, indicate that without considerable copper or nickel such alloys are very soft at 212 deg. F.

	Composition Sn	Pb	Sb	Cu	Ni	Brinell Room	212 deg. F.
I	50	50	..	..	..	14½	7
II	48	48	4	..	..	18½	8
III	44	44	12	..	..	25	9½
IV	42	42	16	..	..	28½	13
V	40	40	20	..	..	30	13½
VI	40	40	15	5	..	43	23
VII	40	45	10	5	..	30½	12½
VIII	40	40	15	3	2	29½	16
IX	40	40	12	3	5	31	17
X	40	40	9	3	8	34½	18
	100	..	..	..	..	13	5
		100	..	..	..	6	4
			100	..	..	49	34½

Fig. 16—Effect of temperature upon the impact resistance (Izod test) of white-metal bearing alloys.



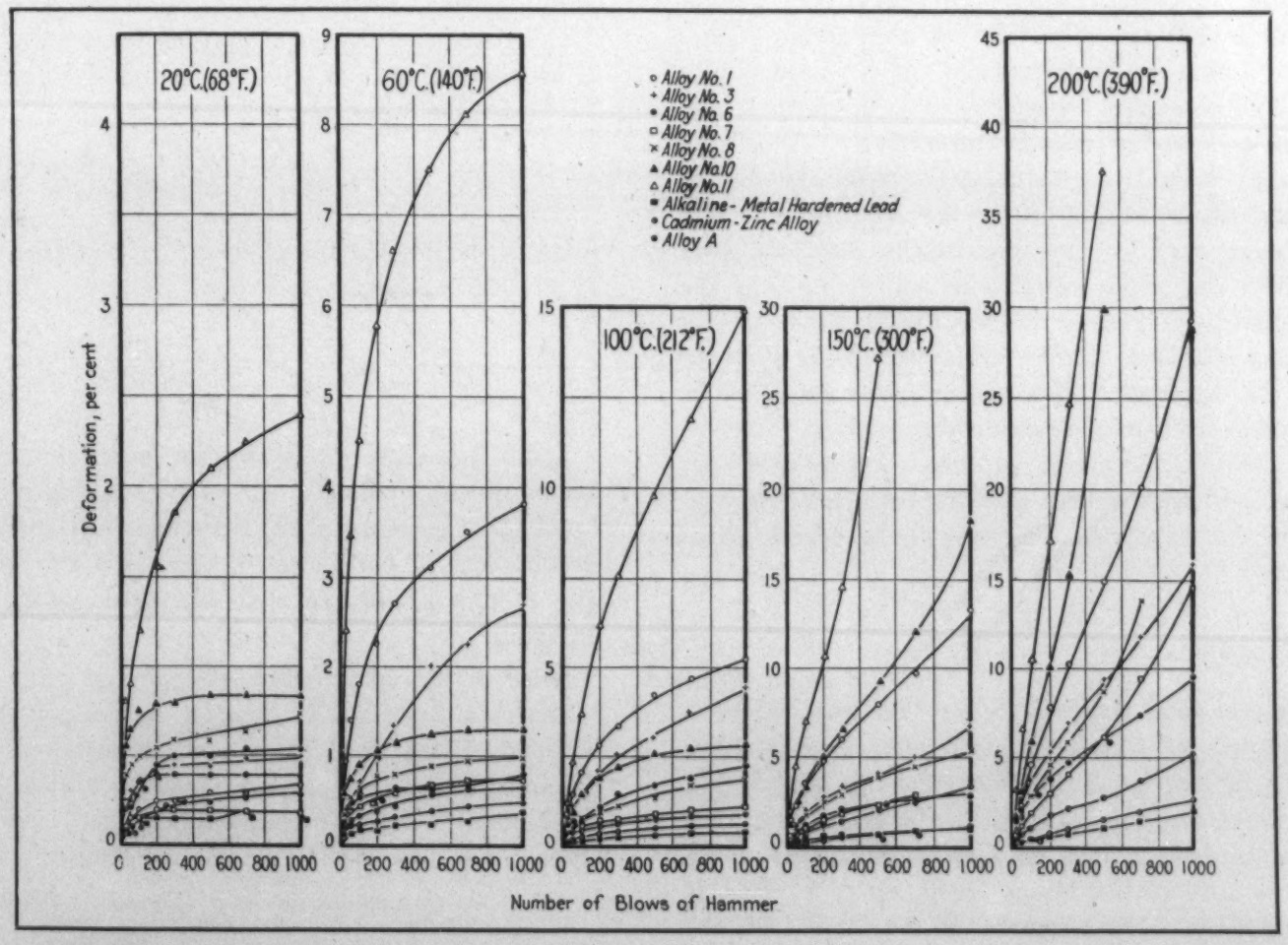


Fig. 15—Relation of deformation to number of blows of hammer at different temperatures in pounding tests. Energy absorbed by specimens for each blow of hammer was approximately 0.33 ft. lbs. Note change of scales.

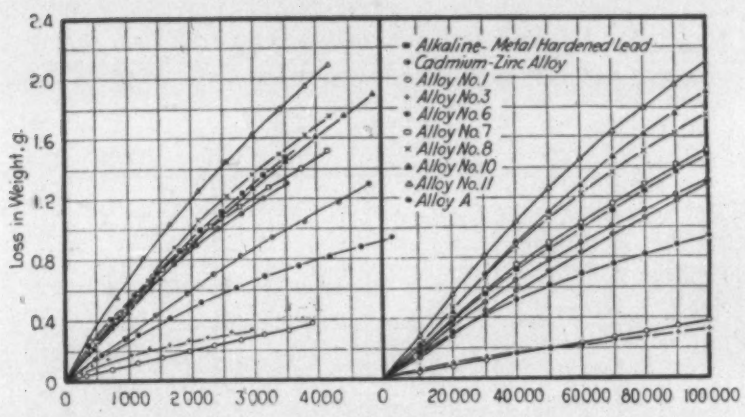


Fig. 17—Relation between wear and revolutions, and wear and work for white-metal bearing alloys tested on Amsler wear testing machine. All alloys were tested against S.A.E. 1045 steel heat-treated to give a Brinell hardness number of 240, under light load and flooded with kerosene.

The A.S.T.M. specifications B23-26 contain two intermediate alloys, the No. 6 cited by Herschman and Basil, and

					Brinell	
	Pb	Sn	Sb	Cu	Room Temp.	212 deg. F.
No. 5	18	65	15	2	22½	10

Bierbaum[65] says that A.S.T.M. Nos. 5 and 6 have a soft matrix which contains the Pb-Sn eutectic (melting at 360°F.) for which reason they become soft and mushy at a relatively low temperature, hence they are not to be recommended for either service or economy as compared with Nos. 4 and 7 with 75 per cent Sn and 75 per cent Pb respectively. The hope one might have from the strategic point of view of reducing tin consumption by the addition of large amounts of lead to a tin-base babbitt does not work out from the engineering point of view. On the other hand, increasing the tin much above 10 per cent in a lead-base babbitt, which would be shunned from the strategic point of view is equally to be shunned from that of engineering.

Corse[38] cites the use of babbitts with 40 to 45 per cent each of lead and tin as axle bearings on foreign railways, but such practice seems to have been abandoned.

Hard Babbitts

Both the room temperature and the elevated temperature hardness can be raised by piling in large amounts of the hardening elements, Sb, Cu or Ni, and As, but to do so leads to brittleness.

Some tin-base alloys, so highly alloyed as to be feared because of brittleness, show up to 11 Brinell at 300 deg. F. The German "W.M. 80 F," 80 Sn, 11 Sb, 9 Cu is so reported by Kühnel.

Von Schwarz[66] describes a group of lead-base alloys with the trade name "Palid" containing antimony and very unusually high amounts of arsenic, an element tabooed by previous workers because of the brittleness of the alloys high in arsenic. He cites:

	Composition			Brinell			
"Palid"	Pb	Sb	As	Room	150 deg. F.	200 deg. F	250 deg. F.	300 deg. F.
Hard	81	13	6	29	23½	20	16½	12
No. 6	86	8	6	23	18	14½	12	6½
Soft	90	5	5	19	16	13½	11	6½

The No. 6 alloy is his "preferred composition" which he considers equal to tin-base babbitt, though none but laboratory tests are cited. It will be noted that its hardness at 300 deg. F. is not so high as that of the harder of the usual tin-base alloys.

It will be noted that there is a very wide gap between the range of hardness of the usual tin- and lead-base babbitts and the range 20 to 30 Brinell at 300 deg. F. for the straight Cu-Pb alloys or those with up to 1 per cent of some strengthening element to be discussed later. In this gap we have only the alkali-hardened leads and the Cd-base babbitts, with about 11 to 14 Brinell at 300 deg. Nothing seems to be in commercial use with a 300 deg. Brinell of 15 to 20. Homer and Plummer[67] found an alloy of 78 Sn, 10 Sb, 7 Cu, 5 Cd to have increased high temperature strength, but it was brittle. A 97 Cd, 3 Ni alloy coming within this range has been described[60] and Losana and Gloria[68] reported on a still harder alloy carrying also 1½ per cent Cu and ¾ per cent Zn beside the 3 per cent Ni.

	Deg. F.			
	Room	212	285	300
94¾ Cd, 3 Ni, 1½ Cu, ¾ Zn	50	33	23	22½
97 Cd, 3 Ni	47	29	—	18*
78 Sn, 10 Sb, 7 Cu, 5 Cd	28	17	14½	—

* Interpolated.

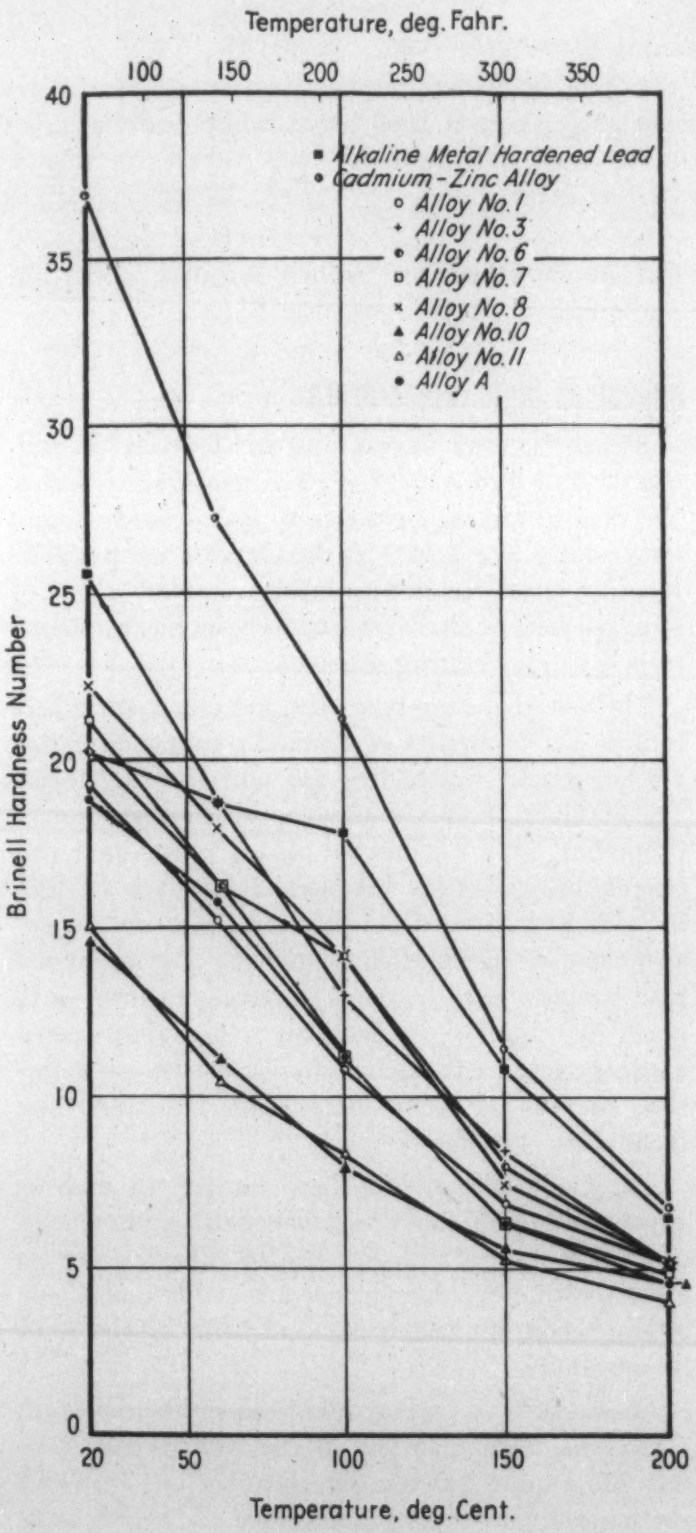
Small amounts of magnesium materially harden cadmium and Kühnel[40] shows hot hardness curves for a 1½ Cu, 1 Mg, 97½ Cd alloy, with 20 Brinell at 300 deg. F. but Bassett[39] notes that such a babbitt, in thin linings, becomes embrittled, and cracks, on aging.

Some of the alkali-hardened leads are often cited as showing the relatively high hot hardness found by Herschman and Basil for the one they tested. For Bahnmetall 98.6 Pb, 0.7 Cd, 0.6 Na, 0.04 Li, 0.02 Al, Kühnel[40] cites the following, unaged, and after aging for 6 days at the elevated test temperature.

	Deg. F.					
	Room	140	175	212	250	300
Unaged	36	30	26	22	19	12
6 days at temperature	36	30	19	14	13	10

These alkali-hardened leads show precipitation-hardening and agglomeration-softening characteristics. Although much harder than hard tin-base babbitt at room temperature, they may soften with time at operating temperature. It might here be noted that

Fig. 18—Brinell hardness of white-metal bearing alloys at different temperatures.



similar, though less marked, precipitation-hardening and agglomeration-softening characteristics are quite common in lead-base alloys so that the permanence of hardness needs to be established. These phenomena may account for some of the discrepancies in the hardness data in the literature.

The Bahnmetall type of hardened lead seems to have found little use outside of railway car journal service, and it is stated by Zunker[69] that in axle bearings on high speed trains it is being found unsatisfactory and is being replaced by tin-base babbitt.

A babbitt of this general category, Satco, has been tried in American railway car journal service, but

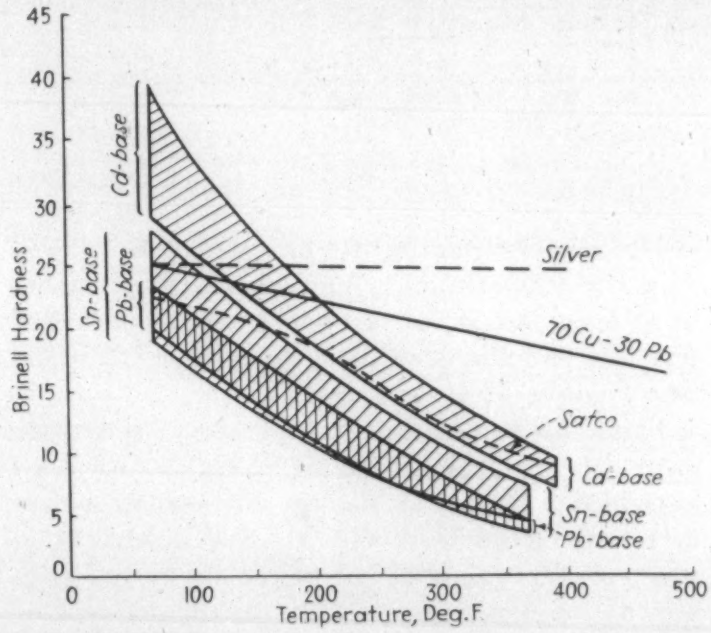


Fig. 19—Hardness-temperature relations of lining metals.

does not seem to have been adopted for regular use. It is in use in some diesel engines, that do not operate at high speed. The composition of Satco is never given with exactness, but in its modern form it appears to contain about 1.5 to 2 per cent Sn, 0.50-0.75 per cent Ca with small traces of Al, sometimes about 0.25 per cent Hg and small traces of Li and other metals. According to Hack[70], Satco, in its modern composition, shows at room temperature, 22 Brinell; at 212 deg. F., 15; at 300 deg. F., 11; and at 350 deg. F., 9.

The more common cadmium-base babbitts are shown by Willi[43], Addick[50], Bloomstrom, and by Swartz and Phillips[64], to run as follows:

Composition					Deg. F.					
Cd	Cu	Ag	Ni	Room	100	150	200	250	300	390
98.25	0.75	0.50	...	38	35	28	22½	17½	13	6½
98.7	...	...	1.30	33	..	..	22½	..	..	6½
97.50	0.50	2.00	...	40	..	..	20	..	13	8+

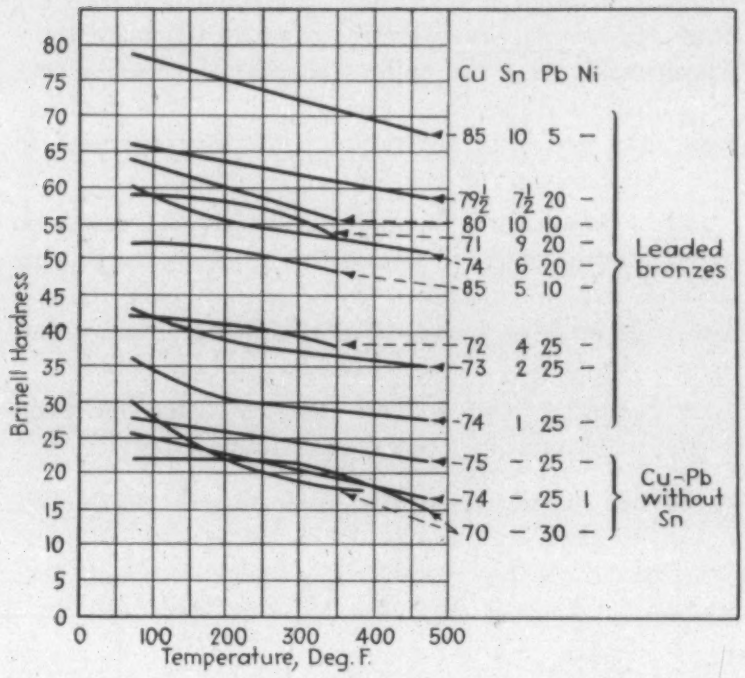


Fig. 20

Little is available on the hardness of babbitts at very low temperatures. Ito[72] reports that a babbitt of 88.8 Sn, 7.4 Sb, 3.7 Cu which, by his method of test, had 31.5 Brinell at room temperature, 11 at 300 deg. F., gave 52 at —55 deg. F.

From the hardness data cited above, and many more data in the literature[73 to 82], Fig. 19 has been assembled. Owing to slightly different techniques in measuring hardness and to some differences in structure, depending on rate of cooling as well as to presence of impurities, the data for any one type of alloy show some variation, but the trends of the different classes of babbitts are quite clear. Only commercial alloys are included in Fig. 19.

Copper-base Alloys

A 70 Cu, 30 Pb alloy is included in Fig. 19 to show what a different pattern of hot-hardness it has.

The Cu-Pb, leaded bronze and bronze bearing metals lose hardness very little over the range of bearing operating temperatures as is shown in Fig. 20, assembled from data of French, et al[83], French and Staples[84], Staples, et al,[85] Harder and Cole[87], Willi[43] and Kühnel[40]. Note the marked increase in hardness when 1 per cent Sn is added to Cu-Pb.

The high temperature behavior may also be appraised by pounding tests, but the deformability of these alloys is so much less than that of the babbitts that pounding tests of the two classes cannot be directly compared. These stronger alloys are subjected to heavier blows in the pounding test, a 7.15 lb. hammer being used, so that each blow delivers 1.2 ft. lb.

Harder and Cole[87] show that, under this repeated load, certain bronzes give, at room temperature and 350 deg. F.

				Per Cent Deformation at			
				Room Temp.		350 deg. F.	
Cu	Sn	Zn	Pb	100 blows	1000 blows	100 blows	1000 blows
88	10	2	..	1	3.5	2	3.5
80	10	..	10	2.3	3.5	4	7
70	5	..	25	9	..	11 at 60 blows	..
	No. of blows for 5 per cent deformation						
75	1.5	..	23.5	30±	..	10±	

Dayton[51] reports that, at 300 deg. F., annealed cast pure silver deforms 12.5 per cent at 100 blows and 15 per cent at 1000 blows, while a similar alloy of 97 Ag, 3 Pb deforms 9 per cent at 100 blows, 11.5 at 1000.

Silver and the high silver, low lead alloys hold their room temperature Brinell hardness, about 25, unchanged at 212 and 300 deg. F.

Impact at High Temperature

French[80] shows impact data for bronzes of various tin and lead content at room temperature and at 350 deg. F. varying from 2 to 10 ft.-lbs. Izod at room temperature and 2 to 7 at the elevated temperature. It is not clear that impact resistance as measured by standard tests on massive material bears much relation to behavior in bearing service.

The data that have been cited indicate that tin-base babbitt has properties at operating temperature that are not exactly matched by any other bearing metal. The Pb-Sb-Sn, lead-base alloys approach them in most properties, but are somewhat lacking in hardness. Attempts to increase the hardness of lead-base babbitts by adding more hardening elements may not be carried too far, else brittleness results. The cadmium-base babbitts have hardness-temperature curves very much like those of tin-base, but at a slightly higher hardness level. Satco is softer than the cadmium-base babbitts at room temperature, but about like them above 200 deg. F.

The Cu-Pb alloys, even those without tin, and the silver and Ag-Pb alloys have materially greater hardness at operating temperatures, so they are not an exact substitution, though they are usable under conditions where tin-base is not, and hence might often be substituted.

Leaded bronzes and straight bronzes have so much greater hardness than any of the babbitts that they fall into a quite different category, but one in which another problem, that of replacement of tin in bronze, is presented.

The possible extent of substitution for tin babbitts and tin bronzes in a time of tin shortage will be discussed, in the light of the properties here given, in the next installment.

(To be concluded)

Bibliography

[36] A. F. Underwood. "Automotive Bearings, Effect of Design and Composition on Lubrication." *Am. Soc. Testing Materials,* Symposium on Lubrication, 1937, p. 29-44.

[37] A. F. Underwood. "Automotive Bearing Materials and Their Application." *S.A.E. Journal,* Vol. 43, Sept. 1938, p. 385-392.

[38] W. M. Corse. "Bearing Metals and Bearings," 1930, 383 pages.

[39] H. N. Bassett. "Bearing Metals and Alloys," 1937, 428 pages.

[40] R. Kühnel. "Werkstoffe für Gleitlager," 1939, 427 pages.

[41] General discussion of Lubrication. *Proc. Inst. Mech. Engrs. (London),* Vol. 1, 1932, 648 pages (see p. 115, 314); Vol. 2, 507 pages.

[42] A. M. Swigert. "The Story of Superfinish," 1940, 672 pages.

[43] A. B. Willi. "Engine Bearings from Design to Maintenance." *S.A.E. Journal,* Vol. 45, 1939, p. 513-523.

[44] A. B. Willi. "How Materials Affect Plain Bearing Performance." *Machine Design,* Mar. 1940, p. 43-47.

[45] "Lead Bronze Bearings." Copper Development Assoc. (London), Pub. No. 33, 1938, 45 pages. (Trans. from "Bleibronzen als Lagerwerkstoffe," Deutches Kupfer-Institute, Berlin.)

[46] E. Lay. "Bleibronzelager für die Motorindustrie." *Metallwirtschaft,* Vol. 17, 1938, p. 1199-1205.

[47] H. R. Ricardo and J. H. Pitchford. "Design Developments in European Automotive Diesel Engines." *S.A.E. Journal,* Vol. 41, 1937, p. 405-414.

[48] W. Bungardt and G. Schartberger. "Aber die Thermische Ausdehnung von Gleitlager Legierungen." *Z. Metallkunde,* Vol. 31, 1939, p. 240-244.

[49] J. W. Cuthbertson. "The Elastic Properties of Some Antifriction Alloys at Room and Elevated Temperatures." *J. Inst. Metals,* Vol. 69, 1939, p. 209-231.

[50] L. Addicks. "Silver in Industry," 1940, p. 167.

[51] R. W. Dayton. "The Possibilities of Silver-rich Alloys as Bearing Materials" with discussion by G. A. Zink, *Metals and Alloys,* Vol. 9, 1938, p. 323-328. R. W. Dayton. "Low Lead-Silver Alloys for Bearings" with note by E. A. Ryder, *Ibid.,* Vol. 10, 1939, p. 306-310, 324. (See also Chapter 8, ref. 50.)

[52] C. F. Smart. "Indium-treated Bearing Metals." *Trans. Am. Inst. Mining & Met. Engrs.,* Vol. 128, 1938, p. 295-310, t.p. No. 900.

[53] H. L. Evans and S. T. Harrison. "Recent Developments in Bearing Metals." *Chemistry & Industry,* Vol. 58, 1939, p. 122-123.

[54] U. S. Pat. 2,136,655 and British Pat. 510,124, July 27, 1939.

[55] S. J. Shoemaker. Discussion *Am. Soc. Testing Materials-Am. Soc. Mech. Engrs.* Symposium on Effect of Temperature on the Properties of Metals, 1931, p. 334-338.

[56] National Lead Company, French Pat. 851,686, Jan. 12, 1940.

[57] A. T. McDonald. "Some Factors in the Lubrication of High Speed Diesel Engines." *Mech. Eng.,* Vol. 61, May 1939, p. 356-358.

[58] C. M. Larson. "Engine Lubrication with Different Bearing Metals, Especially Copper Lead." *S.A.E. Journal,* Vol. 35, 1934, p. 444-453.

[59] D. J. Macnaughtan. "Some Factors that May Determine the Service Life of Tin-base Bearing Metals." General discussion of Lubrication, *Proc. Inst. Mech. Engrs. (London),* Vol. 1, 1937, p. 187-195.
"The Improvement of White Bearing Metals for Severe Service." *J. Inst. Metals,* Vol. 55, 1934, p. 33-47.

[60] C. E. Swartz and A. J. Phillips. "A Comparison of Certain White Metal Bearing Alloys, Particularly at Elevated Temperatures." *Proc. Am. Soc. Testing Materials,* Vol. 33, Part 2, 1933, p. 416-425.

[61] S. T. Harrison and E. Wood. "A Flow Test for Bearing Alloys." *Metal Ind. (London),* Vol. 51, 1937, p. 639-640.

[62] H. K. Herschman and J. L. Basil. "Mechanical Properties of Whitemetal Bearing Alloys at Different Temperatures." *Proc. Am. Soc. Testing Materials,* Vol. 32, Part 2, 1932, p. 536-555.

[63] "Werkstoff-Handbuch Nichteisen Metalle." Deut. Gesellschaft für Metallkunde, see p. 314—Zinn-Lager metalle.

[64] E. Hertel and A. Demmer. "Stauchdiagramme und Wärmehartekurven, Einiger Legierungen auf Pb-Sn-Sb Basis." *Metallwirtschaft,* Vol. 10, 1931, p. 125.

[65] C. H. Bierbaum. Kent's Mech. Eng. Handbook, 11th edition, 1939, p. 462-467.

[66] M. F. von Schwarz. "Neue Blei- und Aluminium Lagermetalle." *Giesserei,* Vol. 27, 1940, p. 137-144.

[67] C. E. Homer and H. Plummer. "Mechanical Properties of Some White Bearing Metals and Other Tin Base Alloys at Various Temperatures." Internatl. Tin Research & Develop. Council, Pub. No. 7, Series A, 1937.

[68] L. Losana and C. Gloria. *Chimica e industria,* Vol. 17, 1935, p. 159-163.

[69] P. Zunker. "Versuche zur Entwicklung eines Lagermetalle auf Blei-Grundlage." *Metallwirtschaft,* Vol. 12, 1940, p. 223-230, 247-253.

[70] C. H. Hack. "Lead-alkali Bearing Metal." *Product Engr.,* Vol. 6, 1935, p. 456-457.
"A New Bearing Metal, A Lead Base Alloy." *Metal Progress,* Vol. 28, p. 61-64, 72.

[71] L. C. Bloomstrom. "Cadmium Silver Copper Bearing Alloy." *Product Engr.,* Vol. 6, 1935, p. 364-365.

[72] K. Ito. "The Hardness of Metals as Affected by Temperature." *Sci. Reports,* Tohoku Imp. Univ., Vol. 12, 1923, p. 137-148.

[73] "Metals Handbook," Am. Soc. Metals, 1939 edition, p. 1332, 1553, 1721.

[74] J. N. Kenyon. "Effect of the Addition of Lead on the Hardness of Certain Tin Base Bearing Alloys at Elevated Temperatures." *Proc. Am. Soc. Testing Materials,* Vol. 33, Part 2, 1933, p. 430-447.

[75] C. Upthegrove. "Automobile Bearing Metals," *Am. Soc. Testing Materials* Symposium on Developments in Automotive Materials, 1930, p. 78-91.

[76] O. W. Ellis and G. B. Karelitz. "A Study of Tin-Base Bearing Metals," *Trans. Am. Soc. Mech. Engrs.,* Vol. 49-50, MSP 50-11 p. 13-1927-1938. *Ibid.,* Vol. 51, MSP 52-7.

[77] A. H. Munday, C. C. Bassett and J. Cartland. "Whitemetal-Antifriction Metals." *J. Inst. Metals,* Vol. 28, 1922, p. 141.

[78] A. L. Boegehold and J. B. Johnson. "Engineering Requirements in the Automotive Industry for Metals Operating at High Temperatures." *Am. Soc. Testing Materials-Am. Soc. Mech. Engrs.* Symposium on Effect of Temperature on the Properties of Metals, 1931, p. 169-193.

[79] E. R. Darby. "Properties of Bearing Metals at Normal and Elevated Temperatures." *Ibid.,* p. 316-331.

[80] J. R. Freeman, Jr., and R. W. Woodward. "Some Properties of White Metal Bearing Alloys at Elevated Temperature." *B. S. Tech. Paper 188,* 1921.

[81] J. R. Freeman, Jr. "The Physical Properties of the A.S.T.M. Tentative Standard White Metal Bearing Alloys." *Proc. Am. Soc. Testing Materials,* Vol. 22, Part 1, 1922, p. 207-211.

[82] J. R. Freeman, Jr. and P. F. Brandt. "Effect of Impurities on the Compressive Strength and Brinell Hardness of Babbitt Metal at Normal and Elevated Temperatures." *Proc. Am. Soc. Testing Materials,* Vol. 24, Part 1, 1924, p. 253-257.

[83] H. J. French, S. J. Rosenberg, W. L. Harbaugh and H. C. Cross. "Wear and Mechanical Properties of Railroad Bearing Bronzes at Different Temperatures." *Bur. Standards J. Research,* 1928, p. 343-421.

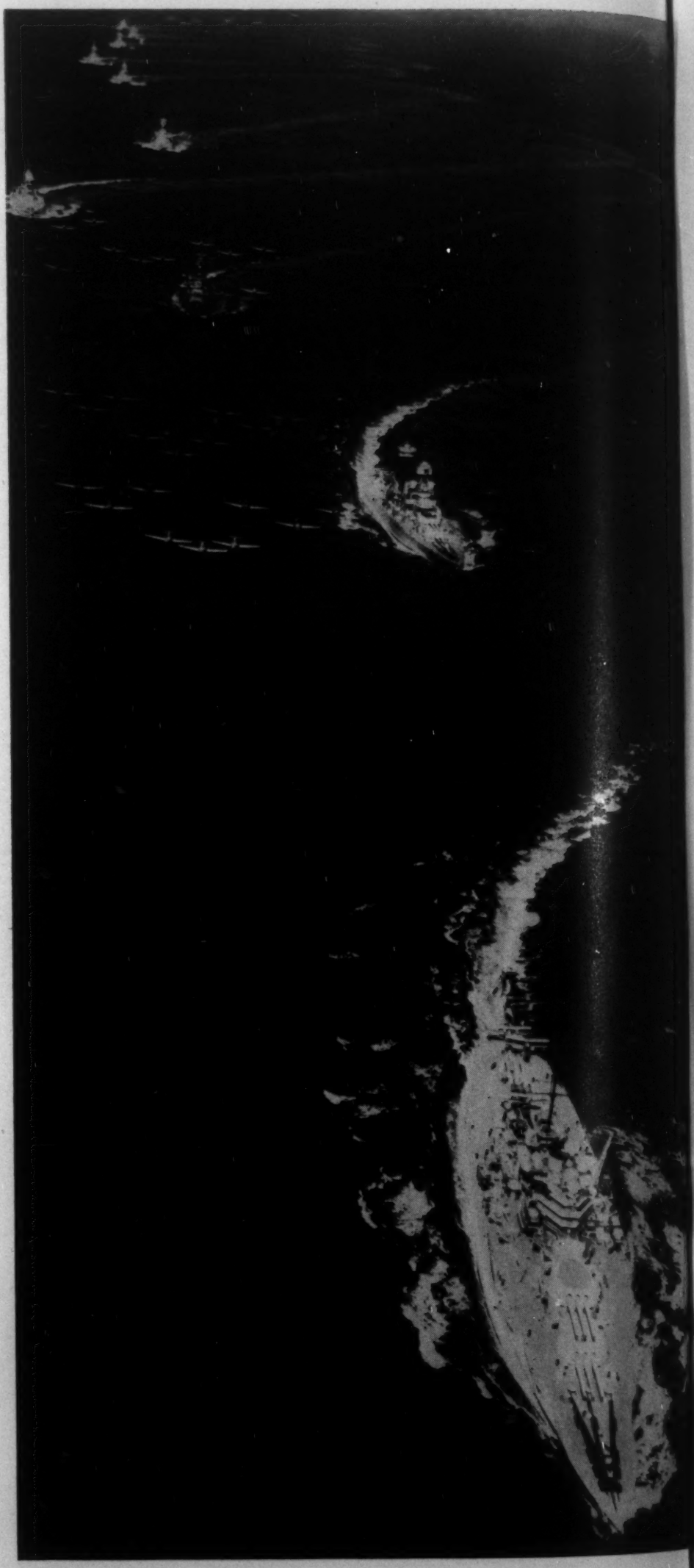
[84] H. J. French and E. M. Staples. "Bearing Bronzes with and without Zinc." *Bur. Standards J. Research,* 1929, p. 1017-1038.

[85] E. M. Staples, R. L. Dowdell and C. E. Eggenschwiler. "Bearing Bronzes with Additions of Zn, P, Ni and Sb." *Bur. Standards J. Research,* 1930, p. 249-264.

[86] H. K. Herschman and J. L. Basil. "Tin-free Leaded Bearing Bronze." *Bur. Standards J. Research,* 1933, p. 591-608. Res. Paper 551.

[87] O. E. Harder and C. S. Cole. "A Study of Six Bearing Bronzes." *Trans. Am. Foundrymen's Assoc.,* Vol. 41, 1933, p. 314-327.

Metallurgical Engineering in Preparedness and Defense



In October we devoted the entire issue of METALS AND ALLOYS to articles and reviews on Metallurgical Engineering in Preparedness and Defense. In this and some subsequent numbers we are presenting other articles of the same general nature.

In this issue, we publish two articles in this classification. One is a brief pictorial presentation of the United States Air Corps Technical Schools, through the courtesy of the Chief of the Air Corps of the War Department. The other is a discussion, from the strategic viewpoint, of the tin plate and solder situation by Dr. H. W. Gillett.

Both of these feature articles are closely related to the Defense Program and supplement those in our October issue. Others will appear in December.—E. F. C.

Tin Plate and Solder

—From the Strategic Viewpoint

by H. W. GILLETT

As a material vitally necessary in many industries affecting the life of the average American citizen, tin is one of the most important of the strategic metals. We are dependent on foreign sources for this metal. The most vital need for tin on the tin can, for example, "is neither on the outside exposed to the atmosphere, nor on the inside exposed to the contents, but at the soldered seam in order to make soldering easy," says Dr. Gillett.

The author discusses the major and minor uses of solder, the quantity of tin necessary, certain possible substitutes and the economic and metallurgical engineering problems involved.—E. F. C.

ACCORDING TO U. S. BUREAU OF MINES statistics the tin content of finished manufactures in the U. S. A. for 1937 was, in rounded figures, 90,000 long tons of which 73,000 was primary and 17,000 secondary tin. As everybody knows, all our tin must be imported and from such locations that temporary interference with shipments by a hostile power has to be taken into consideration.

Tin plate accounted for 39,000 tons, all primary tin. Tin cans for food products are, of course, the most important product using tin plate. Something like 60 per cent of all tin cans are used for food products. Many of the non-food packaging methods based on black plate containers, suitably lacquered, or on non-metallic containers, glass, waterproofed paper or fiber, etc., would serve in a pinch where availability rather than cost is concerned.

Plenty of glass plants are equipped to make milk bottles, and the shift to jars for food packaging would not be difficult. Shipping costs with the heavier containers are a drawback. Aluminum might be used to a limited extent, but it is unlikely that it will be used in "throw-away" containers to replace tin cans. Such things as the big cans used for collecting milk could reasonably be made of aluminum instead of heavily tinned steel. Some miscellaneous uses for tin, now served by hot dip coatings, such as that on copper wire to be rubber insulated, where the tin coating is needed to prevent attack upon the copper by the sulphur in the rubber, might be served by thinner coatings, applied by the replacement process[1] or by electroplating.

Tin Coating Serves Three Purposes

In tin cans for food packaging, the tin coating serves three purposes: It protects the outside of the can from too rapid rusting in storage, it protects the inside from corrosion by the contents, and it allows soldering of the body seam at a high rate of production in modern can-making machinery.

The first purpose can be served by a lithographing or similar coating of the lacquer-enamel type. The second is of importance when packing wet and corrosive materials but is not essential for a surprisingly large number of dry foods, oils, and non-corrosive materials. In fact, many of the wet foods could be safely packed in "enamel" lined, untinned cans, particularly if the lining were applied after the can was formed.

Probably not more than 10 per cent of the total cans made really require the presence of tin from the point of view of protection against corrosion from the contents, since adequate protective coatings other than tin are available. Considering the size of the cans used for various purposes, perhaps not more than 5 per cent of the present tin requirement is really needed to defeat corrosion.

There has been talk of replacing the tin can by silver-coated steel, which may be good publicity for silver, but is poor economics when applied to the general run of throw-away containers. As containers for perfumery and Elizabeth Arden cosmetics, silver linings may have their place. In the food industry it might turn out that the small proportion of violently corrosive fruits, etc., might reasonably be packaged in the silver-coated cans in a pinch.

Soldering gasoline tanks. A zinc chloride flux is first brushed on the terne plate shell and fitting, then a 40 per cent Sn—60 per cent Pb wire solder is applied with a torch, while the joint is still hot, flux is again brushed over the joint to allow the solder to flow readily. A stream of water is then used to assure rapid cooling. This work is done on an assembly line. (Courtesy: Ford Motor Co.)

Aluminum-coated steel has been hailed in the Sunday supplements as the answer to the tin-can problem, but is not an answer until the problem of soldering onto the aluminum is solved.

The Most Vital Need for Tin

The most vital need for tin on the tin can is neither on the outside, exposed to the atmosphere, nor on the inside, exposed to the contents, but at the soldered seam, in order to make soldering easy.

Ordinarily it is cheaper to coat the black plate completely with tin on both sides than to try to "stop off" the areas outside those which will form the seam in the completed can, but in case of acute tin shortage such an expedient might be resorted to, more easily in plated than in hot-tinned material, and methods for its application are under study.[2] The pre-tinned seam areas would allow fabrication of the can by soldering in the normal fashion, the tin on the other 95 per cent or more of the area would be saved.

It is, of course, possible to join the can body by welding[3] rather than by soldering, and, although it is quite a trick to weld such thin stock, it can be welded, thus saving both the tin of the tin plate for which black plate is substituted, and that in the solder. Welding will require installation of new equipment in place of the body-making equipment of present can lines. So until welding apparatus is installed, can making has to depend on soldering.

Thus, there is a way out from the difficulties of a tin shortage for practically every important use of tin plate. Some of them would take some little time to put into effect, a period that can be bridged by a reasonable stock-pile of tin. This chief use of tin is not the most difficult one for which to find replacement.

Tin Requirements for Solders

The annual solder requirement for making the nation's cans is estimated at 3,500 to 4,000 tons of tin as solder against 40,000 tons of tin in all tin plate. This application accounts for only about 1/5 of the total annual use of tin in solder, since in 1937 some 20,000 tons of tin was used in solder, or 22 per cent of the total tin used for all purposes. Some 12,000 tons was primary, and 8,000 tons, secondary tin. Solder is the second greater use of tin, surpassed only by that in tin plate. Solder leads the next largest uses of tin, those in babbitt and in bronze by a wide margin, since each of these takes only around 6,500 tons.

In view of the fact that much tin plate could be substituted by black plate solder is nearly, if not quite, the one use for tin that could not be quite easily materially reduced in time of tin shortage

Hence, the question, how may we solder or join the materials that are now soldered with tin solders, in case tin is not available, is one of the most vital in the strategic economy of tin.

The obvious suggestion, to use a solder higher in lead and lower in tin, is not a correct answer. Ordinary economics have already led to the use, in each type of application of solder, of that tin content giving the lowest over-all cost. Less fluid solders lead to thicker joints, thicker joints are weaker, and when amount of tin used and quality of work are balanced, it is unusual that any over-all saving is accomplished by the use of a lower grade solder than that now in use, except as a plant may be using just one standard grade of solder in order to avoid keeping track of different grades for different uses.

Of course the best way to save solder is not to solder at all, but to weld or copper-braze where those methods of joining are applicable, and they are applicable in many cases. However, such a shift involves the purchase of welding equipment or copper-brazing furnaces and the training of the workmen in their use. Doubtless, many such shifts away from soldering methods would be economical in the long run, and each plant's practice ought to be examined and appraised from that point of view as well as in the light of strategic considerations.

Major Uses of Solder Are Manifold

The uses of solder are so manifold that one cannot name or classify them all, nor if they were classified, are statistics available as to the tonnage requirements in each class. However, some of the larger tonnage uses are obvious.

The largest single use for solder is in automobile radiators. Something over 2 lbs. tin as solder is required per radiator. In a 4,000,000-car year, it is estimated that about 9,000 tons of tin, i.e., nearly half the annual consumption of solder is required for this one purpose.

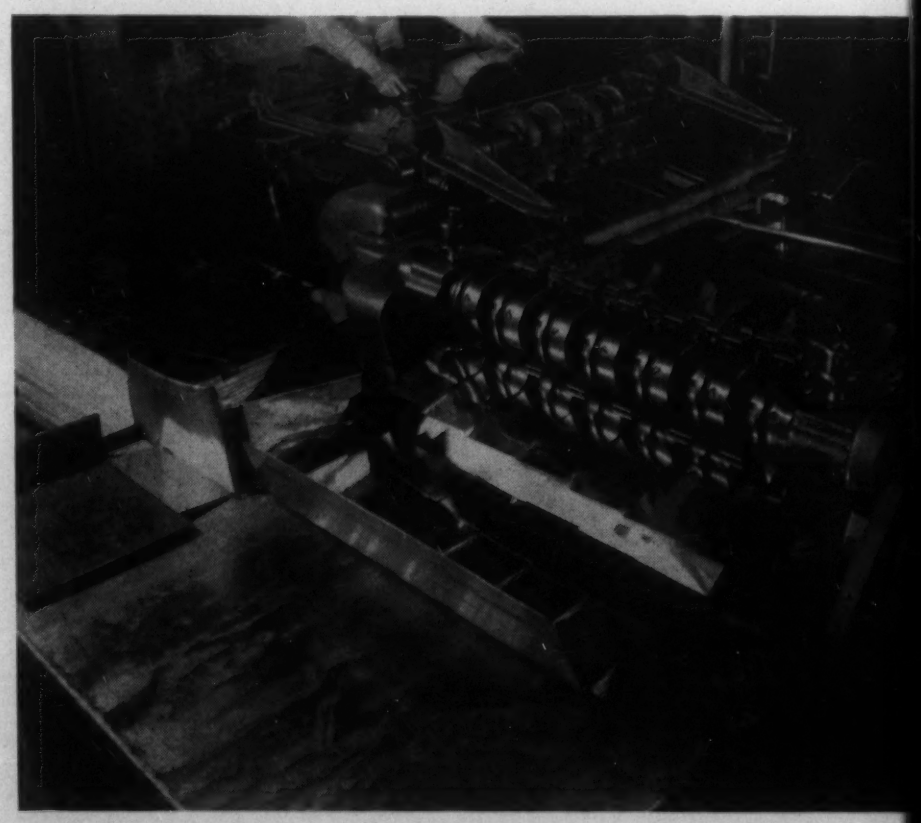
Another automotive use is in "body solder," which is not used to make joints, but merely to even up dents and smooth over welded joints before lacquering the body. The only requirements are that the solder shall be easily applied and easily smoothed. It does not have to have strength. Hence, a solder relatively low in tin is used. In spite of the low tin content of the solder, this use takes 1/3 to 1/2 lb. tin per car. The maker of one of the "big three" popular price cars uses no body solder, the dents are smoothed out and the welds made so that light grinding smooths them. The other two and a half or more million cars per year account for some 500 tons of tin, the use of which can be entirely avoided.

If we subtract from the annual total, 20,000 tons of tin as solder, some 4,000 tons for soldering cans, 9,000 for radiator solder, 500 for body solder, there is left 6,500 tons for miscellaneous uses, soldering electrical joints, and copper tubing; wiping lead pipe and cable joints; and so on *ad infinitum*.

Minor Uses of Solder

Some apparently minor uses add up to rather astonishing totals. Two drops of solder are used on the base of every incandescent lamp to assure good electrical contact with the socket. This use is estimated to require 100 tons of tin annually. Like the auto body solder, these little blobs of solder have

Slitting tin plate into can body blanks. By using duplex slitters the tin plate is automatically cut first with strips, then with short rectangular sections. (Courtesy: National Can Co.)



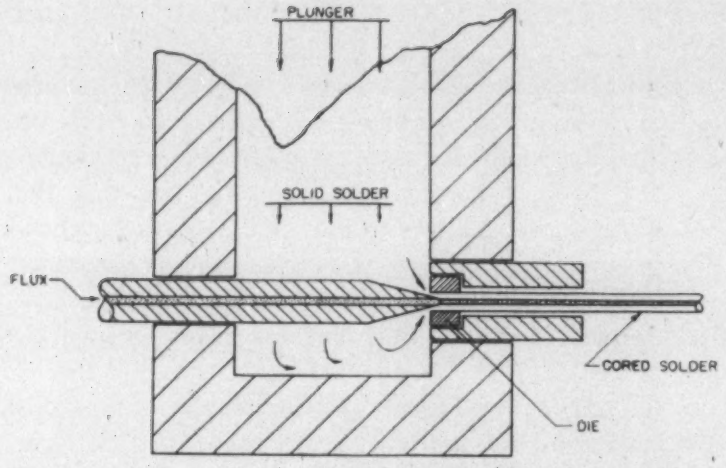


Diagram of a solder extrusion machine for making cored solder wire. Molten solder fills the cylinder, is chilled, then forced by hydraulic pressure through the die. As the hollow wire forms, flux is drawn into the core. Both vertical and horizontal presses are used for making cored wire. (Courtesy: Philadelphia Solder Co.)

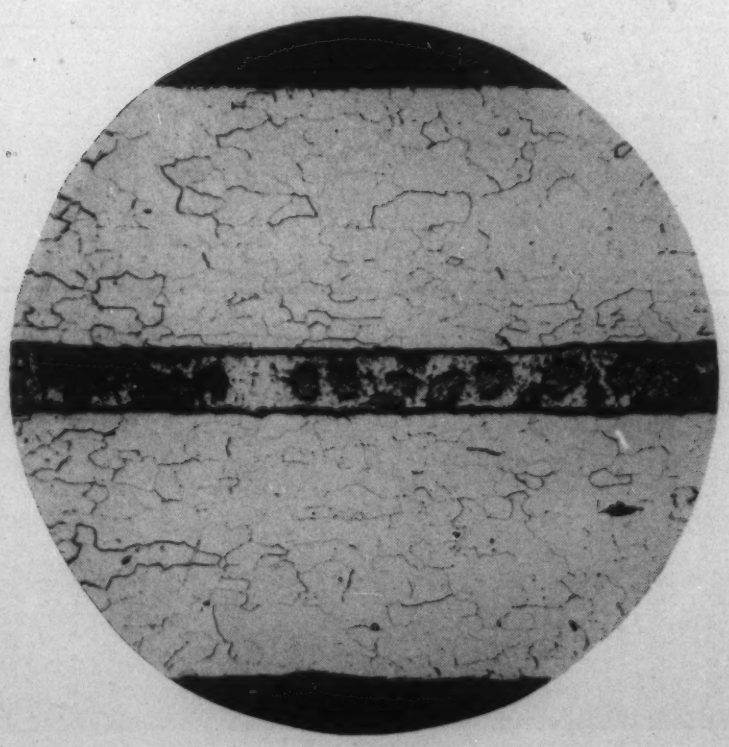
no requirements as to strength, they need only to stick and to be soft enough to deform a bit under pressure so as to make good contact.

If we demand that substitute solders shall not only wet the work nicely and make a strong joint, but shall also have the low melting points of lead-tin solders, we shall probably not find a substitute. If we merely ask for a usable solder that will make a strong joint, then there are substitutes.

Indeed, the "substitute" solders have been worked out, rarely with the idea of merely replacing lead-tin solder, usually for the purpose of finding one that would make an even stronger joint and one that will withstand higher temperature. One case where mere replacement is aimed at is in wiping solder, where the usual 62 Pb, 38 per cent Sn composition can be replaced by 68 Pb, 23 Sn, 9 per cent Cd. At present prices, these cost almost exactly the same.

It has been known for a long time that the Sn-Pb-Cd wiping solder is a usable substitute. It has approximately the same liquidus as, but about 65 deg. F. greater freezing range than, regular wiping solder.

Soldered strips of tin plate, 50 per cent Sn—50 per cent Pb solder. 100X. (Solder in center, tin plate each side.)



High Temperature Solders

The cadmium-zinc eutectic, 82½ Cd, 17½ per cent Zn, melting about 510 deg. F. is a well known solder for service at higher temperatures than those at which Pb-Sn solders can be used. One serviceable at still higher temperatures contains 95 Cd, 5 per cent Ag, with a melting range approximately 735 to 640 deg. F. The high percentage of cadmium in these makes them more costly than ordinary soft solders. Still other high temperature solders are:

97½ Pb, 2½ per cent Ag (sometimes with a little Cu), approximately eutectic composition, melting point about 580 deg. F.

94-95 Pb, 5-6 per cent Ag, freezing range about 700 to 580 deg. F.

All these are in commercial use. The Pb-Ag solders are especially notable for their strength. On a weight basis the low silver solder costs a little over 40 per cent less, the high silver one, at its maximum silver content, about 40 per cent more than a 45 Sn, 55 per cent Pb solder, on the basis of present prices for tin, lead, and industrial silver. On a volume basis the low silver solder is a shade cheaper and the high silver one, 80 per cent higher, than the tin solder.

The 5 to 6 per cent Ag solder is used for soldering aircraft engine radiators for engines cooled with pure ethylene glycol, and is covered by S.A.E. Aircraft Materials Specification 4755. The glycol cooled radiators require that the solder be strong at 330 deg. F. The 6 per cent silver solder meets the requirement, since it has three times the shear strength of 50:50 solder at 350 deg. The Army Air Service and the National Bureau of Standards vouch for the facts that it is not too difficult to handle and that the joints are superior in strength to those made with common solders.

The dipping temperature, in dip soldering radiators with this solder, is about 850 deg. F. instead of the 700 deg. F. for ordinary solder, so that in case the radiator design requires that cold-worked copper, sometimes used in radiator construction, shall not be softened in the few seconds of dipping, it will be necessary to use copper with a high annealing temperature. There are several additions that can be made to copper to accomplish this without much interference with thermal conductivity. Of these, silver is the best known, less than 0.5 per cent Ag

would probably do the trick, and similar effects are produced by small amounts of chromium or several other metals.

In view of the satisfactory service of aircraft engine radiators soldered with Pb-Ag solder, the radiator problem is not serious.

The lamp-base solder can obviously be Pb-Ag just as well as Pb-Sn, and the same is true of a large proportion of the miscellaneous uses for solder.

Utilization of cadmium or silver in place of tin depends on the availability of those metals.

Cadmium and Silver in Solders

Cadmium is a by-product of zinc smelting, the amount available depends on the production of zinc, as there are no ores known that it would pay to work for cadmium alone. The annual world production, at the 1937 and 1938 rate, is but 2100 tons, of which the United States and Canada supplies 1000 tons. Much of this cadmium is used to make bearings of superior properties to tin-base babbitts. Any very large scale substitution of cadmium for tin through use of 82½ Cd, 17½ per cent Zn, or 95 Cd, 5 per cent Ag is therefore not feasible. In wiping solder, 9 per cent Cd replaces 15 per cent Sn, so that such replacement helps just a little from the strategic point of view, and there should be sufficient cadmium available to handle all the wiping solder requirements.

Silver is produced in the United States, in Mexico and Canada. While newly mined domestic silver is bought by the Treasury at a price far above its actual market value, foreign silver for industrial use is available at about 35c per Troy oz., or $5.10 per avoir. lb. In 1939 the United States and Canada used, industrially, 34,000,000 Troy oz., and in that year the Treasury bought over 10 times that amount, which went into storage. The accumulated Treasury holdings amount to around 3 billion Troy oz. or 100,000 avoir. tons.

That amount of silver, much of which, of course, could be released for industrial use in time of stress, would make 2,000,000 tons of 5 per cent Ag solder, equivalent to 1,000,000 tons of tin in 50:50 solder or 50 yrs.' supply. The American Silver Producers have been active in searching for commercial uses for silver, looking toward the time when the Treasury ceases to pay an artificial price for domestic silver

Silver is available in quantity sufficient to make its use in solder thoroughly feasible, not only in a strategic emergency, but under ordinary economic conditions when a solder is required that is strong at high temperature. The inconvenience of a higher temperature of application would have to be put up with.

The Pb-Ag solders are obviously usable for most of the vital solder needs. In can soldering in the regular can production line, the suitability of replacement needs to be demonstrated, but studies are in progress on this point.

In General

One must conclude that in a period of acutc tin scarcity, it will still be feasible to package foodstuffs in containers that require no tin or much less than is now used, and that metals may still be joined by soldering, without necessarily requiring any tin at all, save in the case of wiping solder, in which case some two-thirds of the normal tin content may be dispensed with.

Some of these replacements can be made without material change from present technique, others will require development of equipment and technique. Users of these products might well start to get acquainted with the practice that would be forced upon them in a time of severe shortage of tin, but with reasonable foresightedness in acquiring skill in use of substitute materials, American industry will still be able to function even though tin becomes so scarce that the usual tin plate and solder are not available.

References

[1] "Tinning Copper and Brass by Immersion," METALS AND ALLOYS, Vol. 11, May 1940, pp. 131 to 134.

[2] Canadian patent 388,962 of 1940; French patent 853,936.

[3] U. S. Patent 2,177,104 of 1939; for German plans see Am. Chem. Soc., News Edition, Vol. 18, July 10, 1940; German patent 691,658.

U. S. Air Corps Technical Schools

AN ACTIVITY, intimately related to the Government's Preparedness and Defense program, is the Air Corps Technical Schools with headquarters at Chanute Field, Ill. These are divided into three branches:

1. Chanute Field Branch
2. Scott Field Branch
3. Lowry Field Branch

The Chanute Field Branch gives the following courses: Airplane mechanics, 22 weeks; aircraft machinists, 17 weeks; aircraft welders, 14 weeks; aircraft metal workers, 14 weeks; parachute riggers, 8 weeks; carburetor specialists, 4 weeks; electrical specialists, 4 weeks; instrument specialists, 8 weeks; propellor specialists, 4 weeks; link trainer instructors, 12 weeks; weather observers, 12 weeks; and weather forecasters, 26 weeks.

At Lowry Field the following courses are given: Aircraft armorers, 14 weeks; photography, 14 weeks; clerks (supply) (engineering and operations), 16 weeks; and bomb sight maintenance, 16 weeks.

At Scott Field, a course is given to radio operators and mechanics of 22 weeks.

Through the courtesy of the chief of the Air Corps, U. S. War Department, we reproduce these illustrations of some of their activities—E. F. C.

A class in arc welding in the U. S. Air Corps Technical Schools.

A course in working with sheet metals is another in the Air Corps School.

At the Chanute Field Branch of the U. S. Army Air Corps Technical Schools there is a class in soldering and brazing.

(Editorials continued from page 613)

corollary to this is that the necessary information on properties, compressibility, die design, press capabilities, shrinkage, growth and diffusion in sintering, and all the raw material, time, temperature and power factors that affect costs become rapidly available to industry and its design engineers. Patch points out the benefits that accrued to general industry when it learned to design for die castings, for plastics, etc., not only with respect to the specification of the best form in the first place, but to the intelligent design of the part in full consideration of the peculiarities of the fabricating process chosen.

This is sound advice from one who has seen the results of "designing for powder metallurgy" bring continual expansion and new work to his own plant, and should be heeded by industry's design engineers not now interested in powder compacts, as well as by those vitally concerned with the advancement of this maturing art.—F. P. P.

Letter to the Editor

A Pb-Sn-As Solder for Wiping

To the Editor: This is in reply to a Letter to the Editor appearing in the September issue of METALS AND ALLOYS, page 301, by Clifford L. Barber, research chemist, Kester Solder Co., offering comments on the article, "A Lead-Tin-Arsenic Wiping Solder," by G. S. Phipps and myself, published in the March, 1940, issue of the same magazine.

With regard to the drossing of the arsenic containing solder as compared with lead-tin solders, our observations are in substantial agreement with those set forth by Mr. Barber, so far as these go. When high purity materials and inert containers are used, the lead-tin alloy is relatively free from drossing at the temperatures mentioned so that there is little room for improvement due to the addition of arsenic. However, under practical conditions where alloys are prepared from commercial tin and lead, and used in iron pots which may be frequently overheated, there is substantially less oxidation in the arsenic-containing solder.

Mr. Barber's statement in the last paragraph of his letter is extremely difficult for me to comprehend. I interpret the statement to mean that, if good wetting or alloying of the solder at the surface of the parts to be joined is obtained, then the joint will be sound regardless of the structure of the built-up metal. This is entirely at variance with the actual findings of hundreds of skilled splicers working over a period of many years. Practically all wiping solders "tin" or alloy perfectly on a properly cleaned and fluxed surface but all do not make sound joints. Moreover leaks in wiped cable joints generally occur right through the mass of the solder and not at the junction of the solder and cable.

In our paper we stated that arsenic, when added in proper quantities to lead-tin solder alloys, definitely produced grain refinement and resulted in a markedly superior solder especially from the handling standpoint. The experience on which this conclusion was based was extensive but now it is many times as great. We again say, only more emphatically now, that the beneficial effect of arsenic on grain refinement and handling characteristics is marked.

We believe that a great deal of reliance in appraising solder quality must be placed on the verdict of especially qualified and expert splicers who have conducted extensive practical tests. This new solder was developed accordingly.

EARLE E. SCHUMACHER

Research Metallurgist,
Bell Telephone Laboratories, Inc.

Chuckles

A New Wrinkle in Warfare!

To the Editor: Here is a clipping from the *New York Post* of Aug. 15 which may interest the home owners among your readers.

The Metal and Thermit Co. might also be interested in this new competition.

> A new wrinkle reported in modern warfare are artillery shells, purposely deserted when a battery retires from a position, which shells have been loaded with *termite* and will ruin the cannon muzzles when the enemy tries to fire them from his own guns. [Italics ours].

NATHANIEL HALL,
Chemical Engineer

G. B. Hogaboom Jr. & Co., Newark, N. J.

New Role for Manganese!

To the Editor: I am sure you will be delighted to know that according to the *New York World-Telegram,* issue of Aug. 17, manganese is employed as a "purifier and deodorant" of steel.

T. A. WRIGHT

Lucius Pitkin, Inc. New York

Even *The New York Times* fell for the same error to which our attention has been called by more than one of our readers. One of these follows:

One of the clippings is enclosed for your use on the deodorizing properties of manganese:

> "Manganese is used to purify and deodorize steel. The United States has been accustomed to import it from Russia, India, the African Gold Coast and Brazil."

The association of manganese with fragrance certainly is unusual. In fact, even the comment that manganese is used to "purify" steel can scarcely pass unchallenged.

BRUCE W. GONSER

Battelle Memorial Institute, Columbus, Ohio

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

CLEANING, PLATING AND FINISHING

Recent developments in cleaning and finishing metal parts will interest not only the finishing-practitioner but those many engineers and executives in the various metal-working industries whose job it is to coordinate finishing practice with other metal-processing operations and with product design.

These are the men who must wrestle with the problem of what finish to use, as well as what method and whose equipment and materials to employ once the type of finish has been selected. And sometimes they may see possibilities in not worrying about finishing at all, but instead fabricating their parts from pre-finished metals, which now come in striped, scored, crimped and corrugated patterns. *The American Nickeloid Co.*, Peru, Illinois offers a "Show Me" kit that enables engineers to make tests and cost comparisons between using bonded pre-finished metals and doing their own plating and finishing.

Centrifugal Washer

Designed for use in cleaning departments, plating plants, machine shops, etc., a new centrifuge that washes, rinses and dries small metal parts—all in one machine—has been developed by *Tolhurst Centrifugal Division, American Machine and Metals, Inc.*, East Moline, Ill.

Known as the "Centriforce" washer, the new machine can be used to wash parts with hot cleaning solution to remove oil, grease or dirt. For rinsing, the work is spun in the centrifuge while a spray of hot water swirls through the parts. As a dryer (the use of sawdust is eliminated) the machine is revolved at high speeds while blasts of hot air are forced through and around the parts. Up to 25 batches an hour can be handled.

New Metal Cleaners

A recent addition to the group of alkaline cleaners, reported J. C. Harris of *Monsanto Chemical Co.*, St. Louis, Mo., in a recent paper, is tetra-sodium pyrophosphate. A 1 per cent solution has a pH of about 10.2, which is not markedly alkaline. It is used in combination with other alkalies, such as trisodium phosphate, as it seems to enhance their cleansing action.

Of interest to engineers and executives in charge of departments for plating bright nickel, chromium, cadmium, etc. on brass, bronze and other copper alloys, is an improved method for the electro-cleaning of the buffed basis metal.

Said to eliminate the need for a cyanide dip and a copper strike before bright nickel plating, the new method, known as the Oxbrite process, permits in addition the bright nickel plating of soft-soldered work without preliminary copper plating. An important advantage claimed for the process by its originators, *Oakite Products, Inc.*, New York, is the assurance of freedom from peeling of electroplated deposits caused by poor surface preparation.

Rapid Brass Plating

A new brass plating process claimed to be at least twice as fast as any hitherto in use was demonstrated by the *Electroplating Div. of E. I. du Pont de Nemours & Co., Inc.*, Wilmington, Del., at the Metal Show last month. It is carried out using du Pont high-speed brass salts and anodes in ordinary cyanide equipment. No "breaking in" is required.

Smooth, bright deposits of controllable thickness (over 0.001 in., if desired) can be obtained, and the process operates without polarization at high anode current efficiencies, it is said. Uniform bright yellow deposits are produced over a wide range of current densities and at a relatively low temperature—105-125 deg. F.

Painting and Lacquering

A hammered metal effect whereby steel and other metals can be finished to resemble hammered silver, copper, bronze, etc., is possible through the use of "Hammertone," a newly developed finish of *Maas and Waldstein Co.*, Newark, N. J.

To produce the Hammertone finish, a spray coat of "Codur baking Hammertone Metalustre" of any desired color is applied, followed by a spatter coat with a special Hammertone spatter liquid. This spatter coat forms the hammered-metal pattern and is applied with a low-cost spray gun developed by M. & W.

Modern-design, moderate price and marked efficiency are said to feature a new portable air compressor unit for operating small spray painting equipment, developed by the *DeVilbiss Co.*, Toledo, Ohio.

The new unit (illustrated) is rated at ½ h.p., but is said by virtue of its construction and efficiency to be able to do the work normally assigned to many of the ¾ and 1 h.p. units now on the market. It weighs only 72 lbs. and it holds the medium spray guns at 32-40 lbs., with maximum pressure 50 lbs.

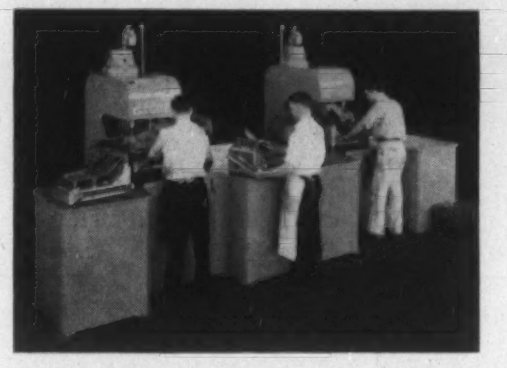
A zinc dust primer consisting of an 80/20 mixture of zinc dust and zinc oxide, and said to be particularly suitable as a primer under aluminum finish paints on steel or on galvanized surfaces, was chosen by engineers in charge of the construction of Consolidated Aircraft's just-completed final assembly building, reports the *New Jersey Zinc Co.*, New York.

● A floor finish of considerable potential utility in pickling, cleaning and plating departments is the new "Glasflex," developed by *Flexrock Co.*, 23rd & Manning Sts., Philadelphia. A dried film of this transparent coating is said to be completely resistant to strong alkalies, acids, solvents and high temperatures.

Spot-Welded Stampings Compete with Die Castings

The effect of processing equipment on engineering design is well illustrated by the case of a leading automobile company that chose to produce an assembled-stampings radiator grille rather than a die-cast unit.

The Progressive Welder Co., 3036 Outer Drive, Detroit, designed and built for this company equipment with which 1,000 stampings are being assembled with 4,000 spot welds into 100 radiator grille-halves per hr. Unique jigs with rubber-tired



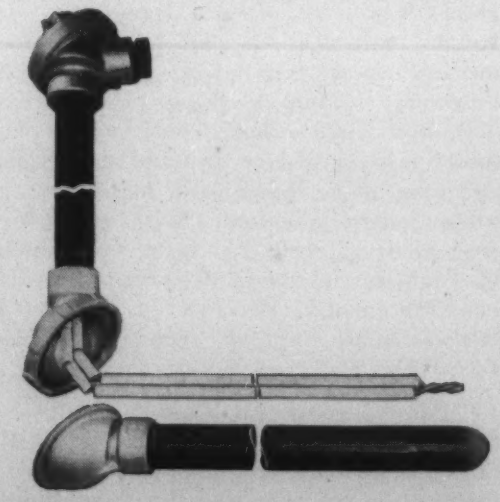
spring-mounted wheels facilitate rapid handling of parts in and out of welding position. Self-equalizing welding tips—2 per gun—permit 2 welds per gun, again doubled by welding through 2 guns in series.

The machine has 2 welding stations with 2 men per station—each loading, welding and unloading the work. The high production it makes possible permits the assembly-welded-stampings to be more desirable than die castings for this company's requirements.

● *Jessop Steel Co.*, Washington, Pa., announces the extension of its line of aircraft alloy steels to include heat-treated and cold-drawn annealed bar products, in addition to sheets and plates heretofore available.

New Thermocouple Fitting

To facilitate thermocouple replacement, a universal union for angle-type couples has now been adopted by *Leeds & Northrup Company*, 4934 Stenton Avenue, Philadelphia. The two halves of this union fit snugly together in a ground joint making it vapor- and fume-tight. By unscrew-



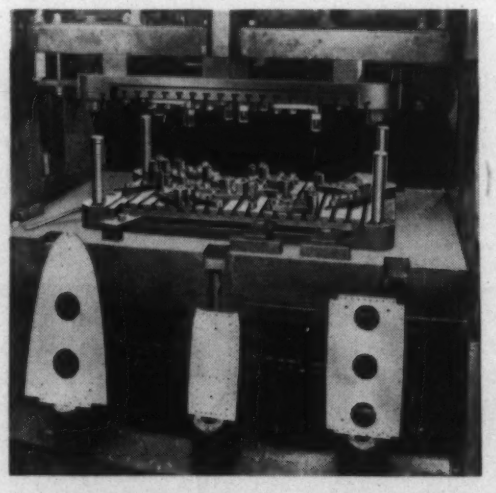
ing a single clamping nut—which cannot fall off—the thermocouple's hot leg can be detached; or it can be rotated to any angle between 90° and 180°, and locked firmly in place.

● Something to put in your "tickler" for attention 5,000 yrs. hence: The Cupaloy Time Capsule (described in our Nov. 1938 issue), a 7-ft. metal cylinder containing the records of our "civilization" and buried in a 50 ft. well on the New York World's Fair site, was sealed for its long rest at noon, Sept. 23, reports *Westinghouse Electric & Mfg. Co.*, East Pittsburgh, Pa.

● A new photoelectric gage that gives a continuous and accurate indication of width variations in moving steel strip without making contact with the metal has been announced by *General Electric Co.*, Schenectady, N. Y.

Adjustable Die Sets

Illustrated here are new universal 100 per cent adjustable die sets for perforating and notching sheet metal recently introduced by *S. B. Whistler & Sons, Inc.*, Buffalo. These are said to be of unusual aid in reducing the time required to get into production on such work and also to answer the problem of economical dies. Once in the user's possession, these die sets can be rearranged as often as desired, putting various sizes of perforating and notching punches in different positions.



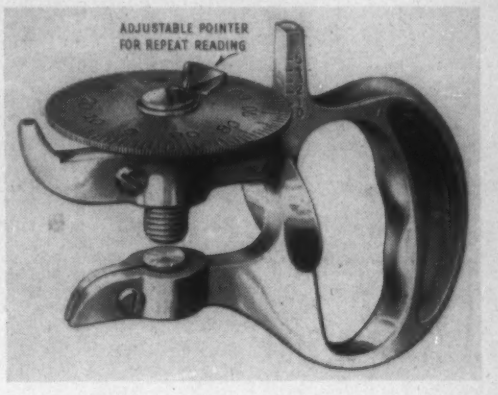
For example, a Philadelphia manufacturer was faced with the problem of producing quickly a limited quantity of some 30 different airplane wing and fuselage sections (some are in foreground of picture), many of which required more than 50 perforations. Conventional die-making would have taken many weeks and the cost would have been prohibitive because of the small volume. But the new adjustable die sets, it is reported, were set up within 3 weeks, ready for production, and at a cost of 1/20th that of other methods.

● *Electro Manganese Corp.*, Minneapolis, Minn., announce their second Research Prize Competition for college undergraduate and graduate students. Three prizes—$300, $200 and $100—will be awarded to prize-winning papers presenting original fundamental research on electrolytic manganese, its alloys, or compounds. For details and conditions, write to the company.

● *The James F. Lincoln Arc Welding Foundation*, Cleveland, is promoting a new program of awards for industrial studies of advances through application of arc welding. There are 458 awards totaling $200,000, and the competition runs until June 1, 1942.

Sheet Metal Dial Micrometer

A handy micrometer for use in gaging all types of sheet metal work has been developed by the *Haines Gauge Co.*, 119 So. 4th St., Philadelphia, to supplement its line of automatic micrometer rolling mill gages.



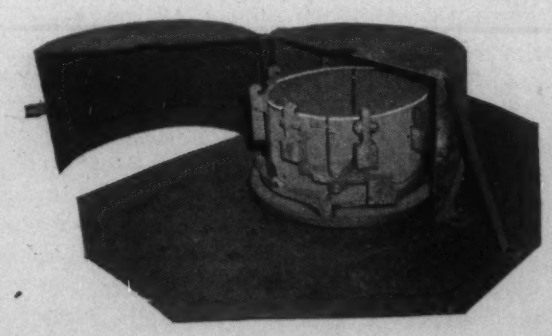
The micrometer, illustrated herewith, is equipped with a 2 in. dial easily readable at arm's length, and the gage is held in the right hand and operated by revolving the dial with the thumb or forefinger, the left hand thus being free to hold the material being gaged. Thicknesses are read from the figures on the revolving dial that fall opposite the vertical post at the edge of the dial.

A special feature is a small pointer on the top of the dial which can be set to any particular gage specified and thus provide an immediate check on the closeness with which the material meets its specifications; reading of the actual figures for thickness is thus unnecessary.

Centrifugal Casting Machines

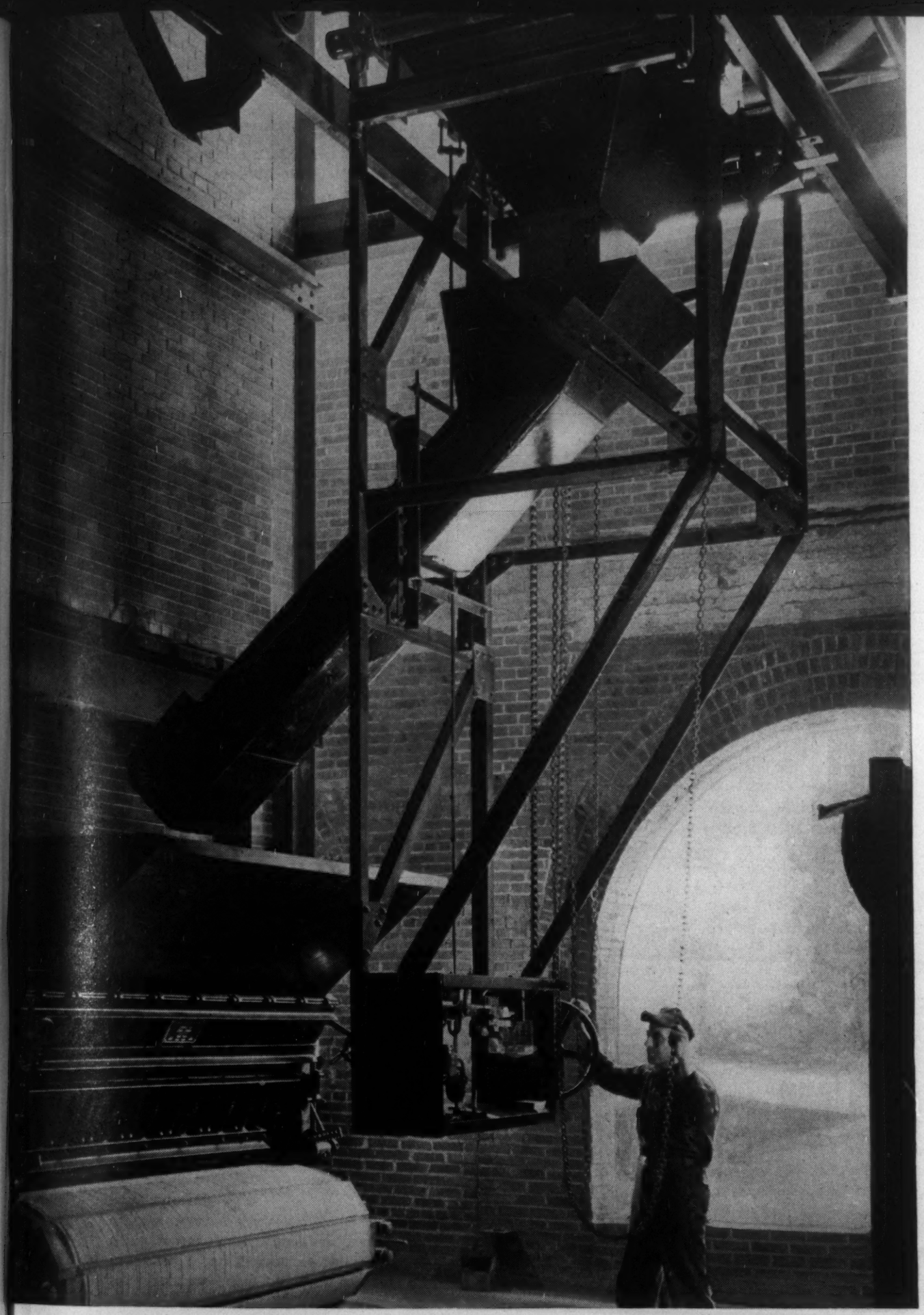
Centrifugal casting offers many advantages for certain types of products. Castings subjected to shock loads, high pressures or heavy wear are improved through centrifugal casting, yields are better and uniformity of properties and structure is excellent.

Vertical centrifugal casting machines (Model A), applicable to the centrifugal casting of steel, alloy steel, iron and nonferrous metals, are announced by *Centrifugal Casting Machine Co.*, Tulsa, Okla. Molds up to 25 in. in diameter and 20 in. high can be spun in these machines, and



both dry sand and green sand may be used. Each unit has complete, flexible speed control from 0 to 1700 r.p.m. and can be operated from any a.c. power source. Many sizes of castings can be poured on the same machine.

Oversize anti-friction bearings are used throughout, and the entire unit is said to be completely dust-proof.



Hopper and Chute of Coal Weigh Larry at Neuweiler Brewery, Allentown, Pa. Built of "A.W." Dyn-el High Strength Steel by Beaumont Birch Co., Philadelphia. Also included in the company's coal conveying equipment is an enclosed Bucket Elevator, with Buckets made of "A.W." Dyn-el High Strength Steel

▲

Typical physical properties of "A.W." Dyn-el High Strength Steel: Tensile Strength—72,000 lbs. per sq. in.; Elastic Limit—58,000 lbs. per sq. in.

They had to fight corrosion . . . To withstand the severe corrosive action of Steam Anthracite Coal, the builders of the coal conveying equipment in the modern Neuweiler Brewery selected "A.W." Dyn-el. This new high-strength steel is 60% to 150% more resistant to corrosion than copper-bearing steel (4 to 6 times ordinary steel). It resists premature failure by fatigue, resists abrasion and reduces weight far below conventional construction. "A.W." Dyn-el High Strength Steel is the first choice of steel buyers for highly stressed parts in structures and mobile equipment of all kinds.

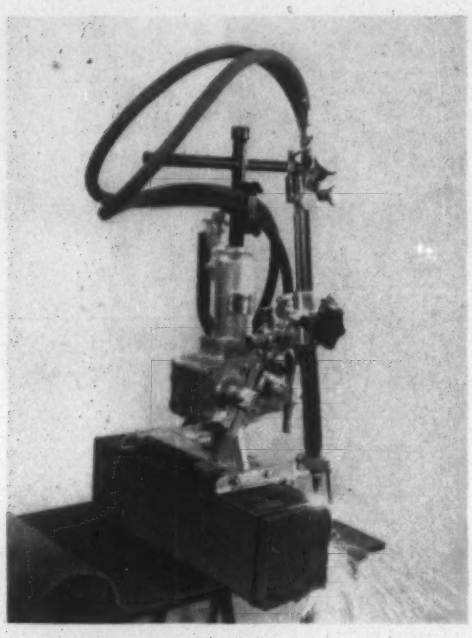
The 48-page book, "A.W." Presents Dyn-el, gives full details of savings in weight and cost possible with this new high-strength, flat-rolled steel. Write for a copy.

ALAN WOOD STEEL COMPANY

MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N.C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

New Bar-Cutting Machine

A new oxyacetylene bar-cutting machine, designed for a number of steel mill cut-off operations, was among the equipment featured by *Linde Air Products Co.*, 205 E. 42nd St., New York, at the recent Metal Show. This portable machine, known as the Oxweld CM-35 bar-cutting machine, will cut rounds or squares with a minimum of adjustment and is driven by a self-contained spring-power unit whose speed is hydraulically controlled.



The new machine is said to do away with the heavy and complicated attachments previously necessary in this type of work. Smooth blow-pipe travel with variation of cutting speeds between 1 and 75 in. per minute is available. The machine can be used indoors or out wherever oxygen and acetylene are available, and can be moved to a new work-place at a moment's notice. With standard equipment, the CM-35 has a cutting range of 2-10 in.

● Anodized aluminum is used for the pistons of 1941 Buick cars because it provides an extremely hard wearing surface with enough porosity to retain the oil film necessary for best lubrication.

Knee-type Hydraulic Press

A new knee-type hydraulic press, of particular interest because it is offered in the much-needed capacities of 5 and 15 tons, is announced by *Denison Engineering Co.*, Columbus. The new press is designed especially to facilitate rapid change of tools or fixtures, and is thus said to be highly versatile for assembling, straightening and other general production pressing for either short-run or high-production work.

In operation the control lever is pushed down, causing the ram to descend until it either contacts the work or reaches the limit of the down stroke. If it contacts the work, pressure will be exerted against it until the controls are released. When the ram reaches the limit of the up stroke it stops, the pressure is released, and pump and motor run idle.

The new presses (type DLKC 2) are available with either manual or electrical controls, the latter offering the maximum in speed and safety. Design modifications for specific or unusual requirements are also available.

● A low-priced grinder for grinding chip-breakers in carbide tools is announced by *Carboloy Co., Inc.*, Detroit, Mich. Chip breakers are essential in the rapidly-growing use of cemented carbides for cutting steel.

● Next time the wife *et al* set up a din about going to the movies, give them something they never expected by taking them to see an industrial motion picture. Two such—"Steel for the Ages," a sound and color film dealing with steel manufacture, and "The Designing of Steel Castings," a sound slide film—are available from *Allegheny Ludlum Steel Corp.*, Pittsburgh, and *Steel Founder's Society of America*, respectively.

Light Metal Plants Expand

Stimulated by preparedness program (particularly aircraft) demands, plants manufacturing and fabricating aluminum and magnesium alloys are adding facilities at an unprecedented rate.

Expansion of *Dow Chemical Co.'s* magnesium manufacturing capacity has been previously noted. *The American Magnesium Corp.* announces that it has underway plant expansion that will triple its fabricated magnesium output, with additions to its foundries, powder plants, sheet mills and die casting shops already completed. *Wright Aeronautical Corp.* is building what it calls the nation's first magnesium foundry exclusively for the manufacture of aircraft engine castings, at Fairlawn, N. J. The same company has also established and is now operating "the country's first line-production foundry exclusively for molding and casting aluminum alloy cylinder heads for aircraft engines for National Defense."

The Reynolds Metals Co. is planning the production of ingot aluminum with the aid of a $16 million loan from the R.F.C. at a proposed plant at Sheffield, Ala., to be capable of producing 60 million lbs. annually. And the *Aluminum Company of America* has allocated more than $150 million for expansion to meet defense requirements, much of the new construction for which is already under way.

● Plastics are gradually finding new applications in aircraft. Airplane tabs inserted in aileron and tail surfaces, previously made of metal, are now being made of laminated phenol fabric for various plane manufacturers by *Taylor Fibre Co.*, Norristown, Pa. And *Glenn L. Martin Co.*, Baltimore, Md., comes forward with a bomb-bay door made of a composite plastic-plywood material, 14 ft. long, 41 lbs. light and able to bear loads of more than 3,000 lbs.

● Corrosion of blades during edging, etching, sharpening, etc., at the Boston plant of Gillette Safety Razor Co. has been practically eliminated through the installation of air conditioning equipment for dehumidifying compressed air, reports *Carrier Corp.*, Syracuse, N. Y.

Aluminum Rivet Heater

The new ACF Berwick electric aluminum rivet heater, illustrated below, has 12 slots on each side of the heater so that 24 rivets can be heated at one time. Its manufacturer, the *American Car & Foundry Co.*, 30 Church St., New York, states that within 3 min. the 24 rivets of practically any size can be electrically heated to 400 deg. F. or in 4 min. to 950 deg. F.

The heater is equipped with fully automatic temperature control so that temperatures between 0 and 1000 deg. F. can be obtained. It may be used for annealing the rivets or for heating them to drive hot.

It is perfectly applicable also for heating up aluminum rods of diameters within the same range as for the rivets, or for making rivet heads, bolt heads, or forgings.

Diameters of the rivets and rods that can be heated run from 1/8 to 1 1/8 in., with heating lengths up to 4 in. possible. The rating of the heater is approximately 16 kva., and it can be built for any a.c. voltage.

● By an arrangement between *National Cylinder Gas Co.* and *Bastian-Blessing Co.*, both of Chicago, National will use the facilities of Bastian-Blessing to engage in the production of a complete line of gas welding and cutting equipment under the "Rego" trademark.

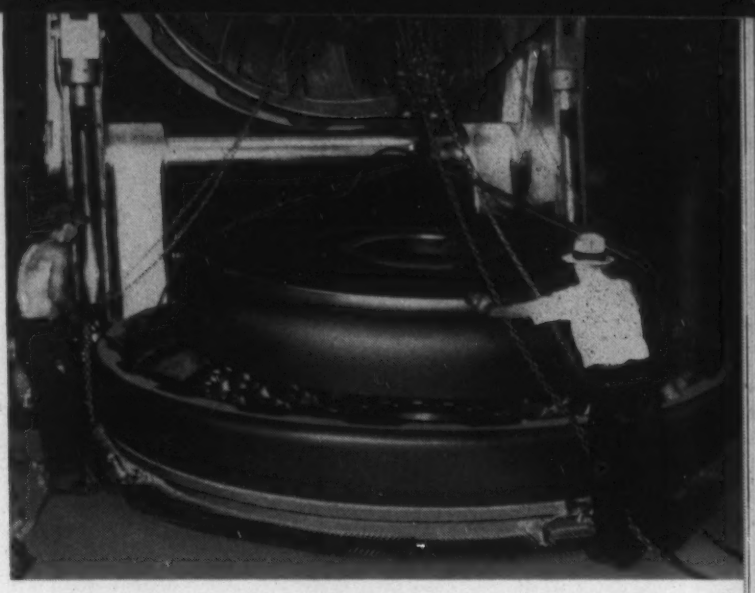
● *General Electric Co.*, Schenectady, N. Y., has added a new 300-amp. size to its line of arc-welding transformers with built-in power-factor correction, similar in performance to the 500-amp. welder previously announced.

New Block and Pipe Insulation

A new 1500 deg. F. insulating material called L-W Superex has just been introduced by *Johns-Manville Corp.*, 22 E. 40 St., New York. Furnished in both block and pipe covering form, the new material is claimed to offer lower conductivity and greater strength for temperatures between 600 and 1500 deg. F.

The new insulation is of the molded diatomaceous silica type but weighs only 20 lbs. per cu. ft. Blocks are furnished 3, 6, 9 and 12 in. wide in standard 18 and 36 in. lengths, and in thicknesses from 1 to 4 in. Curved blocks are also available. Pipe insulation is supplied for standard pipe sizes in segments 3 ft. long and up to 2 1/2 in. thick.

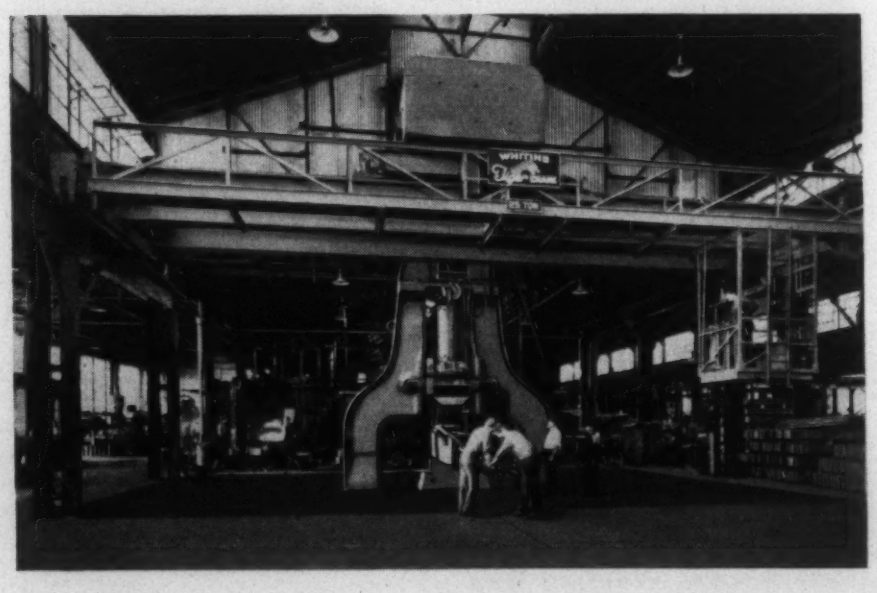
Remember the 24.00-32 Goodyear tire mold described in our July 1939 issue, page 198? Well, here's an even larger mold—for a 36.00-40 (9.5 ft. high) earth mover tire made by Firestone Tire & Rubber Co., Akron. The mold weighs 63,000 lbs., with the tread ring of cast aluminum, the outer mold of steel.



Welding the "world's largest all-welded crane girder" under construction at the Cleveland Crane & Eng. Co., Wickliffe, Ohio. Plates up to 1¼ in. are used; the completed girder will weigh 45 tons and have a 105-ft span.

IT'S COLOSSAL!

some examples of bigger and better metallurgical engineering



This enormous 100-ton testing machine just built by Riehle Testing Machine Div., American Machine & Metals, Inc., E. Moline, Ill., is 34 ft. high, 21 ft. wide and 24.5 ft. from front to back and can exert a maximum pressure of 700,000 lbs. with a maximum error of 0.06 per cent, it is said.

Many layout and construction problems had to be solved by Kropp Forge Co., Chicago, in providing additional space for this new and exceptionally large (14,000 lb.) steam hammer, which will handle a 24-in. billet comfortably.

Another giant girder—this one a 98-ft. job under manufacture by Harnischfeger Corp., Milwaukee, Wis.—being X-ray inspected to check the quality of welds at points of greatest stress.

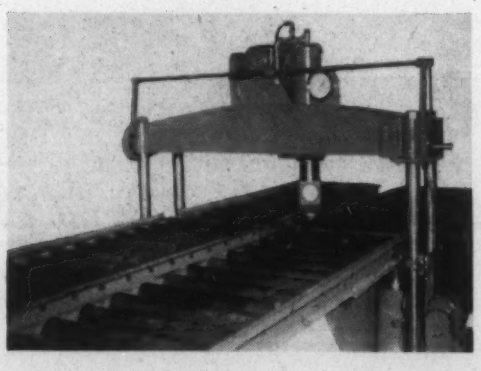
Personals

Colonel G. F. Jenks, Ordnance Dept., U. S. Army, Washington, D. C., has been nominated for 1940-1941 president of the American Welding Society. . . . *Walter Bohnstengel* has been promoted to engineer of tests, Atchison, Topeka & Santa Fé Railway System, Topeka, Kans. . . . *E. L. Roth* has been elected president of Motor Castings Co., Milwaukee, Wis. . . . *D. L. Ogden*, formerly director of metallurgy, has become general superintendent of United States Metals Refining Co., Cartaret, N. J.

Henry J. Fischbeck, chief metallurgist for Pratt & Whitney Aircraft, has become process engineer for that company. . . . *R. O. Griffis*, formerly chief metallurgist for Richard Thomas & Co., Ebbw Vale, England, is now research engineer, Bethlehem Steel Co., Bethlehem, Pa. . . . *H. J. French* and *T. N. Armstrong*, International Nickel Co. metallurgists, have been awarded the American Welding Society's Lincoln Gold Medal for 1940, for their paper on weld hardening of carbon and alloy steels.

Plate Brinell Hardness Tester

A plate Brinell hardness tester for testing wide plate at any point without removal from the conveyor has been added to its line of hardness testing equipment by *Detroit Testing Machine Co.*, 9390 Grinnell Ave., Detroit. The machine consists



of a flat base (not shown in this illustration) and cross-rail assemblies supported by 4 posts. The test cylinder is mounted on a carriage sliding between the rails, and is moved across the plate by a small motor operated by push button control.

A heavy work-support rail runs between the conveyor rollers slightly below flush when idle. In operation the plate passes over the rollers the desired distance and is held in that position by the work-support rail, which takes the load. Tests are then made across the width, the plate is released, moved further and the testing operation repeated.

● The first application of platinum leaf for building decoration was completed in August on the outer vestibule ceiling of the 67 Wall St. building, New York. The leaf is 1/250,000 in. thin, reports the *International Nickel Co., Inc.*, New York.

● For continuous pickling at 210 deg. F., Weirton Steel Co. uses Asplit acid-proof cement to bond the brick lining of its 4 large tanks, reports *Pennsylvania Salt Mfg. Co.*, Widener Bldg., Philadelphia. A free test kit for comparing the properties of its acid-proof cements with other products is offered by Pennsylvania Salt to engineers and executives who write for it on their business letterheads.

● Freight locomotives were sheathed with stainless steel for the first time, reports *Republic Steel Corp.*, Cleveland, when 20-gage stainless was recently used to cover the boiler, runway and cylinders of 2 new engines for Minneapolis & St. Louis R.R.

New Drill Core Bits

Designed to reduce drilling costs, decrease drilling time and eliminate the usual costly reconditioning and resetting of diamond bits, a new type of core bit is announced by *Carboloy Co., Inc.*, Detroit, Mich. In the "Sinta-Set" core bits the entire matrix forming the crown of the bit is impregnated with industrial bort diamonds. This is a departure from the normal practice of hand- or cast-setting of individual diamonds in just the surface of the crown.

The bits can be operated on any type of rotary drilling equipment. The diamonds are said to be considerably smaller and present in much greater number than in conventional core bits and thus insure longer effective life per bit plus elimination of all tendency to "track."

The bits are produced by molding and sintering the matrix material (cemented carbides) in which the dies have been previously distributed. Extremely close tolerances are claimed possible in this way, and the use of a cemented carbide matrix is also said to provide greater resistance to abrasion and therefore longer life.

For sharpening the core bit, Carboloy Co., in cooperation with *Pangborn Co.*, Hagerstown, Md., has developed a simple and compact low-cost universal sand blasting machine composed of a blast cabinet, dust exhauster motor and dust-collector bags; the unit is being marketed by Pangborn, and lists complete for $211. With it, reconditioning time is only 5 min., and the unit is so compact that it may actually be taken into the mine.

Aluminum Bronze Welding Rod

Aluminum bronze in the form of a coated welding rod is now being produced for the first itme, reports *Ampco Metal, Inc.*, Milwaukee, Wis. Known as "Ampco-Weld," the new rod—a real metallurgical engineering innovation—is available in several grades, which provide combinations of hardness, strength and ductility ranging from 60 Rockwell B, 55,000 lbs. per sq. in. tensile and 14-18 per cent elongation, to 38 Rockwell C, 96,000 lbs. per sq. in. tensile and ½ per cent elongation.

These values are said to be better than those available with older bronze welding materials. In one test a 0.505 in. test bar was turned of S.A.E. 1020 steel with a V-notch weld of Ampco-Weld, and tested in a tensile machine. The bar broke (in the steel) after 27% elongation at 84,000 lbs. per sq. in.; the steel had elongated on both sides of the weld section and necked down before fracture, with the bronze weld metal still its original diameter.

Ampco-Weld is said to be in use for rebuilding worn cams, gears, dies and bearing surfaces, as well as in original work where the bearing properties and corrosion resistance of the metal are advantageous.

Meetings and Expositions

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting. New Orleans, La., Dec. 2-4.

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING, Grand Central Palace, New York, Dec. 2-7.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, rubber and plastics subdivision. New York, N. Y., Dec. 5.

NATIONAL CHEMICAL EXPOSITION. Chicago, Ill., Dec. 11-15.

SOCIETY OF AUTOMOTIVE ENGINEERS, annual meeting. Detroit, Mich., Jan. 6-10.

Mechanical Chargers for Small Cupolas

Mechanical chargers, originally restricted to plants with large cupolas melting huge tonnages, are now available for even the smallest cupolas, reports the *Whiting Corp.*, Harvey, Ill. The Whiting skip-hoist charger has so extended the field of mechanical charging, it is said, as to bring its advantages of operating-cost-savings and improved melting practice within the reach of all foundries.

In the skip-hoist charger, the materials are loaded into a skip, which is automatically hoisted, dumped and lowered. No charging floor is necessary. The hoisting mechanism is completely enclosed and is mounted above the floor level. The charger is said to be low in cost and to involve, in its installation, little or no change in existing plant layout.

Free Service Department

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd St., New York.*

HELP WANTED: Silver Solderer. For fine precision brass and steel work—blowpipes, etc. Must be fully experienced. Write giving complete details and salary expected. Business located in Middle Atlantic States. Box MA-31.

HELP WANTED: General Alloys Co. is expanding, and anticipates need of men experienced in all phases of cast heat and corrosion resistant alloy business. Will consider men experienced in furnace engineering or kindred lines. Shop, office, sales and engineering. Write fully stating education, experience in detail, personal details and starting salary expected. Your application will be held in strict confidence. Box MA-32.

HELP WANTED: Young graduate metallurgist with practical knowledge of the processing of stainless steels. Should be competent in metallography and experienced in the investigation of metallurgical problems of stainless steels in production and in the field. Give training and experience. Box MA-33.

HELP WANTED: Young metallurgical or mechanical engineering graduate qualified for general and research machineability work on stainless steels. Some experience in operation of machine tools desired. Must be willing to go through extensive training period. Give training and experience. Box MA-34.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

ADVISORY EDITORS

C. H. HERTY .....*Iron and Steel Production*
G. L. CRAIG .....*Non-Ferrous Production*
J. W. BOLTON .....*Foundry Practice*
S. EPSTEIN .....*Rolling*
A. W. DEMMLER .....*Forging and Forming*
H. W. GRAHAM .....*Machining*
O. E. HARDER .....*Heat Treatment*
HORACE DREVER ...*Furnaces, Refractories, Fuels*
E. V. DAVID .....*Welding and Cutting*
H. S. RAWDON .....*Finishing*
M. GENSAMER .....*Properties of Iron and Steel*
A. J. PHILLIPS ..*Properties of Non-Ferrous Metals*
V. V. KENDALL .....*Corrosion*
H. F. MOORE .....*Fatigue*
H. C. CROSS .....*Creep*
W. A. TUCKER .....*Testing*
L. REID .....*Magnetic Inspection*
G. R. HARRISON .....*Spectrographic Analysis*
J. S. MARSH .....*Ferrous Metallography*
C. S. BARRETT .....*Non-Ferrous Metallography*

ASSOCIATE EDITORS

A. A. Anderson, G. Ansel, W. H. Boynton, A. Brenner, Janet Briggs, W. H. Bruckner, R. W. Buzzard, J. C. Chaston, Frances Clark, A. W. Contieri, B. N. Daniloff, J. W. Donaldson, H. C. Duus, E. Fetz, J. D. Gat, B. W. Gonser, J. L. Gregg, G. E. Guellich, M. E. Haas, M. Hartenheim, C. E. Jackson, C. B. Jenni, J. B. Johnson, H. F. Kaiser, B. Z Kamich, P. R. Kosting, A. I. Krynitsky, D. J. Martin, G. T. Motok, T. Murakami, G. Neuendorff, H. Nishimura, Frank G. Norris, J. M. Noy, V. S. Polansky, H. W. Rathmann, P. C. Rosenthal, C. M. Saeger, Jr., T. Sato, M. Schrero, R. P. Seelig, A. U. Seybolt, N. Shibata, A. P. Som, O. R. Spies, B. H. Strom, K. Tamaru, H. F. Taylor, Cyril Wells, R. A. Witschey.

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hard-facing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

3. Properties and Applications

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

5. General

Articles pertinent to more than one of the previous sections.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Foundry Dust Hazards

A Composite

Dust control is desirable, of course, because poor working conditions and sloppy-looking shops are reflected in inefficiency and lower product quality. The most important argument for systematic dust control, however, is simply that the health of the workers can be seriously affected by excessively dusty atmospheres. This is particularly true if the dust contains much silica, and hence foundries, which do all kinds of dust-making things with silica sand, received special attention.

It is the general opinion that only the very fine silica particles measuring less than 3/2500 in. can lead to silicosis, reports L. M. MERRITT of Ohio Industrial Commission ("The Dust Hazard in Foundries", *Occupational Hazards*, Vol. 2, Sept. 1940, pp. 18-20). Dust is stirred into the foundry atmosphere when unloading the sand from cars, adding silica flour to the mix, tempering the sand for the molds, being handled by the molder, tempering the sand for cores, making the cores, during shakeout, collecting the castings, cleaning, removing cores from the rattler and sand blasting. The most harmful dust may take 24 hrs. to settle to the floor. In many, many foundries little attention is paid to obvious silica dust hazards.

Where simple manual shoveling is employed in tempering sand, the latter is usually wetted down and unless a gyratory screen is used to remove the hard lumps, the actual health hazard is slight. Mechanical sand cutters and aerators, however, stir the wet particles into the air, and men in the plant during this operation should wear respirators. The larger foundries have provided mechanical sand tempering equipment that is well ventilated.

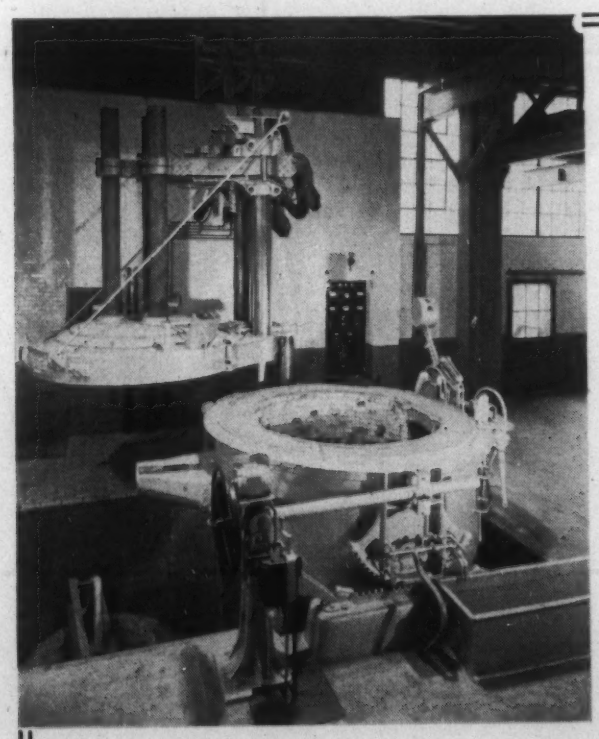
Localized mechanical equipment that removes the sand from the shakeout with conveyors, tempers the sand and conveys it back to the molder on belts is often combined with ventilation that does two things —removes the objectionable "fines" from the sand and removes the dust from the operation. A ventilated belt cleaner should also be employed to prevent the accumulation on the belt of dried sand that would shale off at some point on the belt's return.

Respirators and face coverings are recommended for the operators of sand slingers. Spraying of silica washes on the cores, a common practice in steel foundries, should be done only in ventilated cabinets, and core drilling or grinding should be done on ventilated equipment.

The grinding and sand blasting of castings are other operations that required thorough ventilation. Elimination of the worst dust features of these processes so completely that precision machining operations can be performed only a few feet away is described in a recent note ("Grinding and Sanding Castings Without Dust", *Iron Age*, Vol. 146, Sept. 12, 1940, p. 51).

Ventilation is down-draft. The top of each working station is a large grating, through which air is exhausted to pull away the cloud of rust, sand, paint particles, etc. For large castings 3 floor stations are provided, and are connected by a 54-in. track. The units for smaller castings include a 2-wheel snagging grinder, a horizontal disk grinder, and 4 grinding bucks for supporting castings during work with portable air-driven tools.

All the units are exhausted through the roof, the total amount of air removed being 50,000 ft.^{3}/min. at an average surface velocity of 200 ft./min. The blower equipment comprises 5 Rotoclone type fans located in a small room. X (1)



USE MOORE RAPID *Lectromelt* FURNACES for MELTING REFINING SMELTING

Illustration shows top charge type LECTROMELT furnace with roof raised and rotated to one side to permit quick charging with drop bottom bucket.

LECTROMELT furnaces offer the rapid and economic means for the production of plain carbon and alloy steel ingots and castings as well as gray and malleable irons. Top charge and door charge types are both available. LECTROMELT furnaces are built in standard capacities from 25 pounds to 100 tons. Write for details.

PITTSBURGH LECTROMELT FURNACE CORP.

Foot 32nd St. **Pittsburgh, Pa.**

1a. Ferrous

Flash Welding of Steel Strip

"RESISTANCE FLASH WELDING OF STRIP IN STEEL MILLS." J. H. COOPER (Taylor Winfield Corp.) *Paper, American Welding Soc.*, Oct. 1940 meeting. Descriptive.

Steel users' demands for larger coils of strip than can be rolled on existing hot mill equipment, and the need of larger coils for more efficient processing of the strip in steel mills have made welding of multiple coils a necessity. The resistance flash welding process meets the requirements of high production rate, weld quality and low maintenance cost, with no increase of unit labor cost.

NO WONDER FOUNDRIES ARE SAVING MONEY WITH TRULINE BINDER

This low-cost material can be purchased so economically, and used in so many ways, it's no wonder that so many foundries are saving money.

With this one versatile material, you can make accurate cores that collapse completely, give them a smooth wash, and face your molds, too. Thus, you get sound castings that are clean, smooth, true to pattern.

For Truline Binder* is used as a core binder, a binder in core washes, and an ingredient of mold-facings. It is easy to handle and mix, bakes and dries surely, and resists the cutting action of hot metal. It burns out completely, reduces cleaning costs, and cuts down rejects due to cracks or scabs. Particularly important is its binding action and easy drying in cores containing a high proportion of black sand.

Put Truline Binder to work saving money in your foundry. The coupon below involves no obligation. It is merely a request for more information. Mail it today.

Naval Stores Department

HERCULES POWDER COMPANY

Incorporated

Wilmington, Delaware

CHICAGO NEW YORK ST. LOUIS

SALT LAKE CITY SAN FRANCISCO

33-34 *Reg. U. S. Pat. Off., by Hercules Powder Company

HERCULES POWDER COMPANY
907 Market Street, Wilmington, Delaware

Please send information about Truline Binder ☐

Please send a free trial sample ☐

Name _____

Company _____ Street _____

City _____ State _____

By this process, using no filler metal or adjustable arcs or flames, welds are made with heated areas and sheet warpage only a fraction as great as with other processes. Quality is such that welds and welded strip are often cold-reduced to 10-20% of their original thickness. Welding speeds surpass speeds obtainable by other processes; for example, a ¼ in. x 90 in. strip can be joined in 25-30 seconds.

Requirements to be met at the weld itself are: (1) A proper start of the flashing action, (2) the "flashing-off" or burning away of a sufficient amount of metal for the particular gage of strip under consideration at an optimum rate and optimum welding voltage and current, and (3) a speedy and powerful "upset" or forging action.

Weld characteristics, with an extremely narrow heat-affected zone, are excellent; test values are given for 0.60% carbon A 1, deep-drawing steel. The maximum weld hardness averages 10-15 points Rockwell B over the hardness of parent metal. Tensile tests made on coupons cut transverse to the line of weld always break well outside the weld or heat-affected area. Olsen ductility tests indicate that 610 for unwelded strip *vs.* 552 for welded strip, using a ⅞ in. diam. ball and 1½ in. die, are typical readings.

Metallurgical inspection reveals typical heat-affected areas, but without any zone of deposited metal and all within a very restricted width of affected area. The scavenging action of the arc and the squeezing-out of fluid metal during the forging action essentially eliminates any slag or oxide inclusions.

Electrical power requirements are quite low—approximately 25 Kva/in.^{2} of welded cross section during the flashing operation. This figure is about ¼ the equipment nameplate rating per in. of welded maximum section. The nameplate rating is merely indicative of a means of standardizing equipment and has no direct connection with the power demand during weld. (1a)

Open Hearth Refractories

"Expansion of Various Refractories." Alexander M. Morton (Pittsburgh Steel Co.) *Blast Furnace & Steel Plant*, Vol. 28, July 1940, pp. 665-666. Practical discussion.

Until very recently, most furnace builders allowed for plenty of expansion in chrome brick walls. During 1938 and 1939, the author installed 3 solid brick bottoms in open-hearth furnaces, using 9 in. of chrome and 9 in. of chrome-magnesite brick to form an elliptic shaped bottom, and left no expansion joints in brickwork. When brought up to temperature, there was no sign of expansion in any part of the hearth nor of any crushing having occurred in the brickwork. A number of basic brick shoulders recently installed along front and back walls in open-hearth crowns have shown a decided *shrinkage* in brick, rather than an expansion.

There is undoubtedly a great deal of expansion where magnesite brick are used. In such cases, it is better to use a basic cement in laying these brick, with enough flux in the cement to take care of expansion, rather than to leave expansion joints. In using silica brick, one of the best methods of construction is to lay the brick fairly tight and use insulation blocks against the buckstays to take up expansion. Clay brick has a slight expansion at about 850° F., but this is followed immediately by shrinkage. Binding on any furnace, except a very small and lightly-bound furnace, will take care of the expansion period, and simultaneously, tend to make the wall monolithic.

Cracks have developed in jackets of blast-furnace, due to chemical reactions in the burden, but no one has proved they were caused by expansion in the brickwork. Some day blast-furnace stacks will be of welded construction, making them smooth on inside, and linings will be installed tight against the shell. Expansion joints around the walls in the stove and against the insulation will be forgotten, and the walls made as tight as possible, as they should be.

MS (1a)

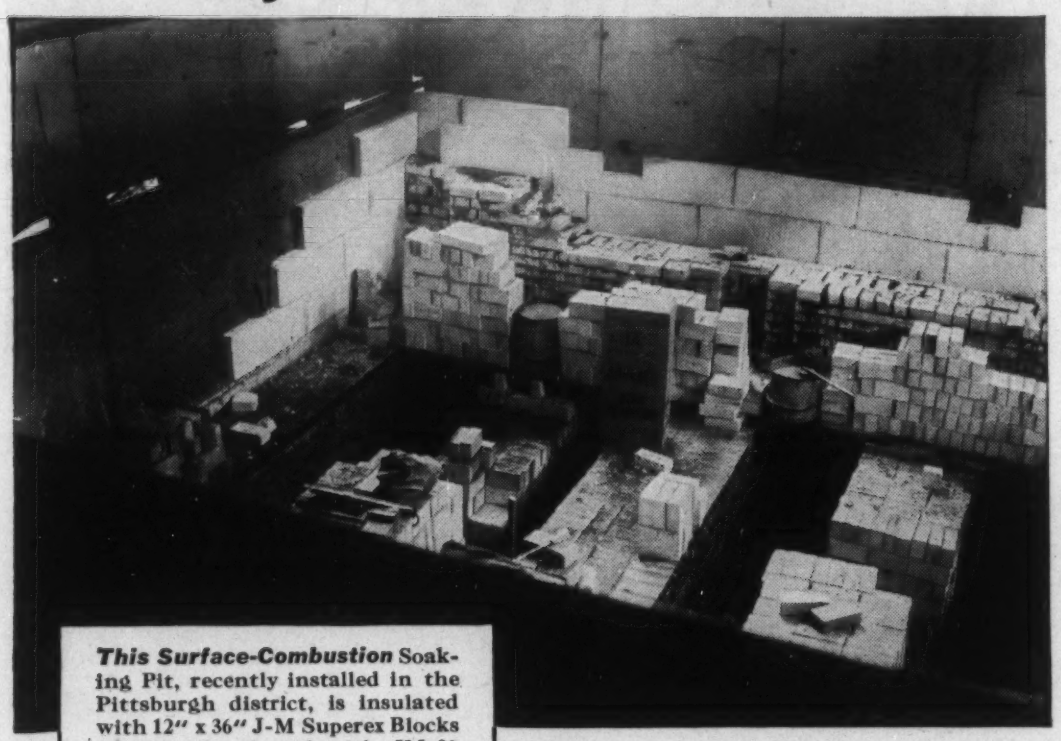
Temperatures for Shearing Bars

"Shearing of Bar Steel." D. M. Henderson, Jr. (Wisconsin Steel Works) *Iron Age*, Vol. 146, July 18, 1940, pp. 33-35. Investigation.

In the plant discussed, the sheared ends of bars were often rough and broken. It was noticed that at certain temperatures, using the same knives and steel of the same specifications and size, unbroken ends were obtained, while shearing at other temperatures resulted in rough ends. It is known that sufficient cold work, such as is done on the bar in the shearing operation causes strain-aging at temperatures within the range where the ends of the bar show color.

The investigation to corroborate this covered 3¼ in. square bar, from the rolling operation to shear. The material (S. A. E. 1040 steel) was sheared at 1200°, 775°, 475°, 400°, and 200° F. Brinell tests of the sheared ends showed that steel in shearing hardens more at temperatures within a certain range than it does at temperatures above or below that range; the tests did not determine the exact temperature at which

Does Your Insulation Investment Pay a *FULL* Return?



This Surface-Combustion **Soaking Pit, recently installed in the Pittsburgh district, is insulated with 12" x 36" J-M Superex Blocks (shown above) and with JM-20 and Sil-O-Cel C-22 Brick.**

HOW much money you spend on fuel depends to a large extent on the answers to these two questions:

Are you using the *correct insulating materials?*

Are they applied in the *correct thicknesses?*

To assure every saving possible with insulation, it will pay you to call in a J-M Insulation Engineer. Let him study your requirements . . . his specialized technical training and experience will help you trace down and correct sources of heat waste that may otherwise go unnoticed.

From the complete line of J-M Insulations, he can recommend exactly the *material* you need for greatest efficiency . . . exactly the *thickness* you need for maximum returns on your investment.

For full details on this helpful service and facts about the complete line of J-M Industrial Insulations, write to Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville

INDUSTRIAL INSULATIONS FOR EVERY TEMPERATURE . . . FOR EVERY SERVICE

Superex . . . 85% Magnesia . . . JM-20 Brick . . . Sil-O-Cel C-22 Brick . . . Sil-O-Cel Natural Brick . . . J-M No. 500 Cement . . . Sil-O-Cel C-3 Concrete . . . Marinite

Cleaner, more homogeneous steels plus higher production yield

TAM ALLOYS in STEEL

High-Carbon
Ferro-Carbon Titanium

Medium-Carbon
Ferro-Carbon Titanium

In many of the country's leading steel plants, TAM High-Carbon Ferro-Carbon Titanium and TAM Medium Carbon Ferro-Carbon Titanium are used to produce cleaner, more homogeneous steels. Beside substantially increasing strength and ductility, these two TAM Titanium Alloys allow a higher production yield.

Plants and products differ so widely, that the only satisfactory way to learn fully how TAM Alloys can improve your product is to call in a TAM field engineer. He will gladly tell you, without obligation, what TAM Alloys can do for you, how to use them, what they will cost. Write: Titanium Alloy Manufacturing Company, Niagara Falls, N. Y.

Are you receiving your copy of the TAM "Monthly Reminder No. 40M"? Each monthly booklet contains valuable information on the uses and effects of TAM Metallurgical Alloys in steel. Write for your copy today . . . it's free.

TAM METALLURGICAL ALLOYS

TAM Original High Carbon FCT (Ferro-Carbon Titanium) No. 78, TAM Medium Carbon FCT No. 35, TAM Foundry Ferro Titanium, TAM High Aluminum FCT, TAM 40% Low Carbon Ferro Titanium; TAM Webbite (Alumino Titanium), TAM Cupro Titanium, TAM Nickel Titanium, TAM Metallic Titanium, TAM Metallic Zirconium plus many other ferrous and non-ferrous alloys of Titanium and Zirconium, as well as fluxes, refractories, foundry facings and metallurgical chemicals. Detailed information on request.

ZIRCONIUM TITANIUM PRODUCTS Registered U. S. Pat. Off.

TITANIUM
ALLOY MANUFACTURING COMPANY

GENERAL OFFICES AND WORKS: NIAGARA FALLS, N. Y., U. S. A.
EXECUTIVE OFFICES: 111 BROADWAY, NEW YORK CITY

Representatives for the Pacific Coast . . . . . BALFOUR, GUTHRIE & CO., San Francisco, Los Angeles, Portland, Seattle, Tacoma
Representatives for Canada . . . . . RAILWAY & POWER ENG. CORP., LTD., Toronto, Montreal, Hamilton, Winnipeg, Vancouver, Sydney
Representatives for Europe . . . . . T. ROWLANDS & CO., LTD., 23-27 Broomhall St., Sheffield, England

strain-aging starts and diminishes. However, these results plus other tests on 2¼ x ½ in. hot flat bar placed the "blue brittleness range," as applied to the shearing type of strain-aging, between 750° and 450° F.; furthermore the range of maximum effectiveness of this type of strain-aging (greatest breaking) is 500°-650° F. Steel sheared at 600° F. not only shows higher Brinell but also breaks more than other samples.

Although the Brinell numbers show no great difference except at 600° F., the condition of the sheared ends indicated precipitation and its accompanying hardening begins in the neighborhood of 750° F. and ends near 450° F. Shearing in this range will result in broken cuts.

In general, pronounced breakage is likely to occur when bars of the following carbon contents are sheared at or near the temperatures indicated (with corresponding temper colors given):

	0.12% C	530° F	Light bronze
	0.38	570	Light purple
below	0.85	600-620	Dark purple—dark blue
	0.85	530	Light bronze
above	0.85	600-620	Dark purple—dark blue

VSP (1a)

Flame Scarfing Billets

"Flame Scarfing Billets." John Hefley (Republic Steel Corp.) *Steel*, Vol. 107, July 15, 1940, pp. 54-55, 76. Descriptive.

Flame scarfing was started at the author's plant in Feb. 1937, and in 1939, 75% of the steel was conditioned by this method, with the percentage still increasing. The speed of the process effectively removes a production bottleneck in the mill.

Using 10 torches, the present maximum output is about 500 tons/8-hr. turn. Output per torch per hr. ranges from 3½ to 12 tons for comparatively short periods. The maximum speed that can be maintained throughout an 8-hr. turn is about 6 tons per hr. One operator with a scarfing torch handles 6-8 times as much steel as he can by chipping. Other advantages of flame scarfing are: Fewer men need be trained, but they must be better trained to do the work properly; cracks and seams, which in chipping would be unnoticeable, are exposed; and the work is much cleaner and easier than chipping.

Natural gas is received at the plant at 14 lbs. pressure and is reduced as it is fed into the main line, which operates at 12 lbs. pressure. It is very important that the gas be dry and reasonably free from sulphur. Torches are of a standard type but have a specially-developed rod feed, which starts the cutting action within 0.01-0.03 min.

Actual scarfing is done at a maximum rate of 85 ft./min., with the average throughout the shop about 40-50 ft./min. A minimum of 1/64-in. of metal can be removed from the surface; the average amount removed is 1/16-3/32 in. deep, taken from a width of ½-⅞ in. "Scabs" can be removed quickly with a light cut of the torch. "Tears" may require more than one pass. "Seams", which may extend the entire length of the billet, are easily removed with a light cut.

Flame scarfing does not alter the metal structure. Steel with not over 0.50% C or alloy steels with not more than 0.35% C are flame scarfed. Those with higher carbon are chipped. MS (1a)

Blast Furnace Slags

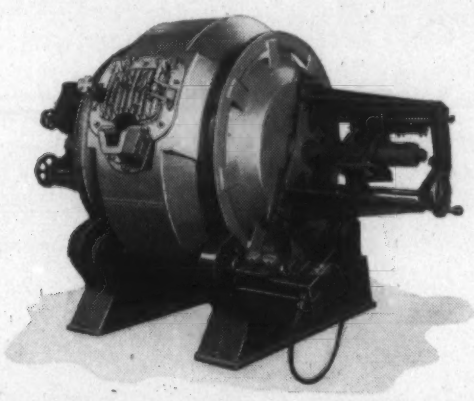
A Composite

With steel melter and foundryman calling for continually better iron and surreptitiously shaving down the sulphur in their pig specifications, blast furnace men have had to do more than just wring their hands and wish desulphurization outside the blast furnace were more widely practical. Study of blast furnace slags and sulphur control therewith has been the iron-maker's answer.

Successful slag practice for producing a low-silicon, low-sulphur pig iron is described by L. F. Sattele of National Tube Co. ("Effect of Magnesia and Low Alumina in Blast Furnace Slags on Furnace Operation and Desulphurization", *Blast Furnace & Steel Plant*, Vol. 28, July 1940, pp. 659-664). A change in specifications had lowered permissible sulphur to 0.025% and silicon to 1.00-1.25%; coke containing 1.00-1.25% S and an ore mix giving 7.5-9% alumina in the slags were used. At the beginning the slag contained 1% MgO and 52% CaO, and operating conditions were poor. The problem was to decrease the CaO without lowering basicity so much as to hamper desulphurization.

The solution was found in increasing the MgO in the slag to above 4%, after which smooth furnace operation together with excellent sulphur control was obtained. A representative slag composition is 34.5-36.9% SiO_2, 7.3-10% Al_2O_3, 48-50% CaO, 4-5% MgO and 1.9-2.2% S. The iron produced averages 1.10-1.25% Si and 0.021% S, manganese being kept at 2/5 the silicon.

Average production has been 856 net tons per day with the carbon ratio 1367 lbs./net



PROFIT with a DETROIT Rocking Electric Furnace

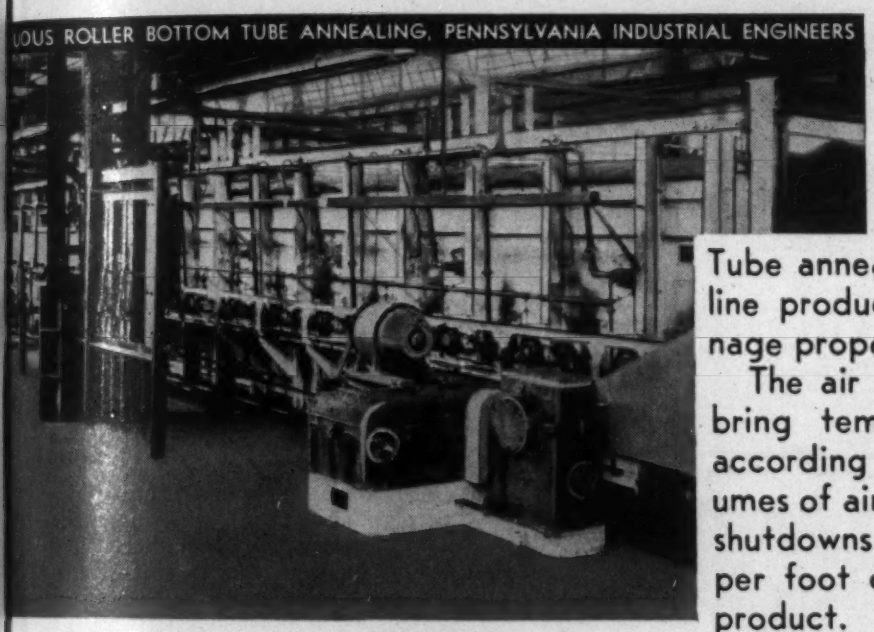
- **Faster Melting.**
- **Lower Metal Losses.**
- **Higher Average Quality of Product.**
- **Less Machine-Shop Scrap.**
- **Saving in Floor Space and Molding Equipment.**
- **Use of Cheaper Raw Materials.**
- **Less Labor.**
- **Saving of Alloys.**

In brief, the **DETROIT** Electric Furnace produces a better product faster at lower cost. But don't take our word for the unusual economy and advantages of this remarkable Furnace. Find out for yourself. We shall be glad to give you the names of a great many outstanding owners. Or better still let us arrange for you to see a few of these furnaces and talk to their owners and operators yourself. **Get the low-down first hand from those who know.** Write for further facts today.

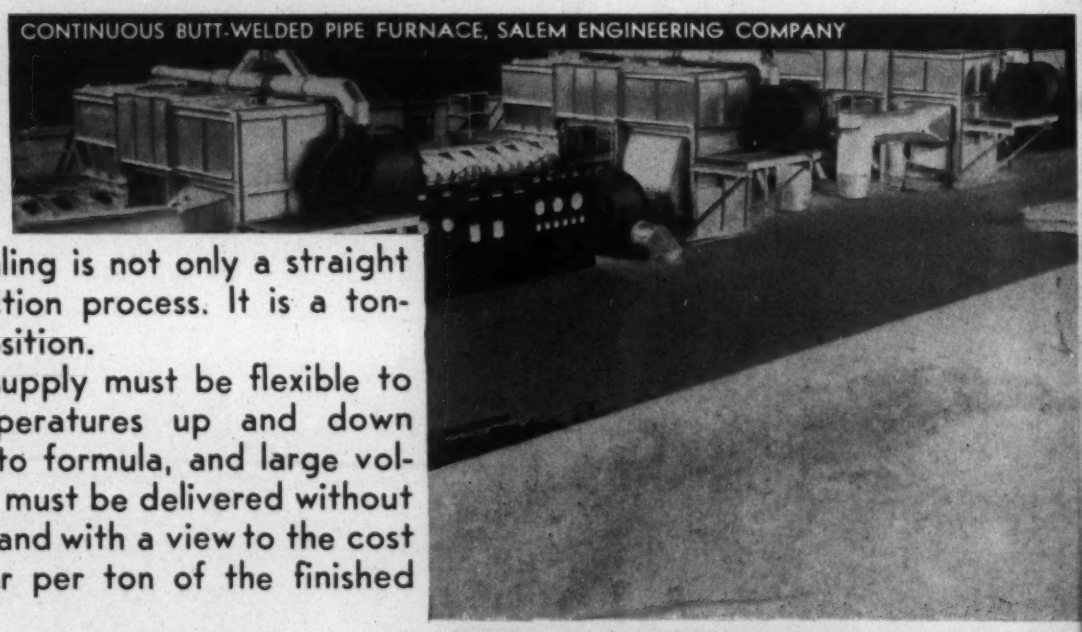
DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY MICHIGAN

TUBE ANNEALING

CONTINUOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS



UOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS



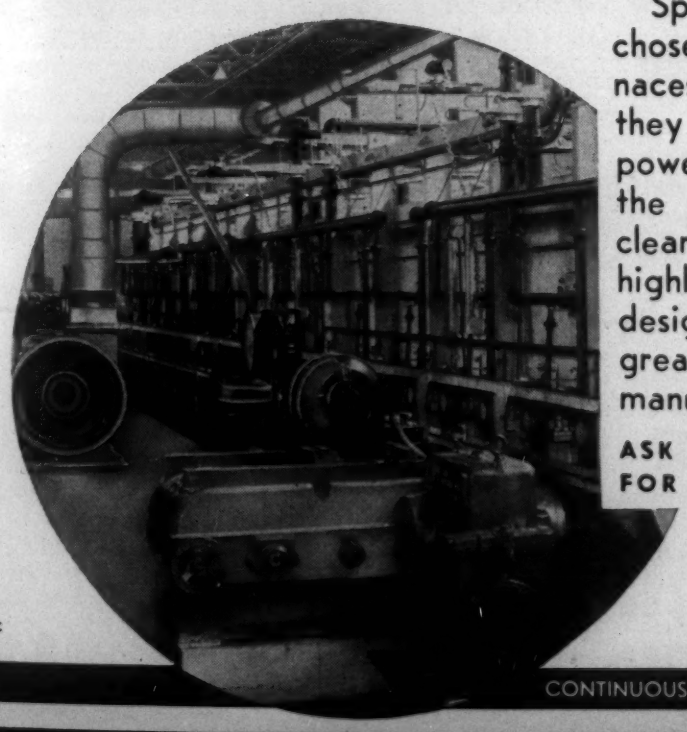
CONTINUOUS BUTT-WELDED PIPE FURNACE, SALEM ENGINEERING COMPANY

Tube annealing is not only a straight line production process. It is a tonnage proposition.

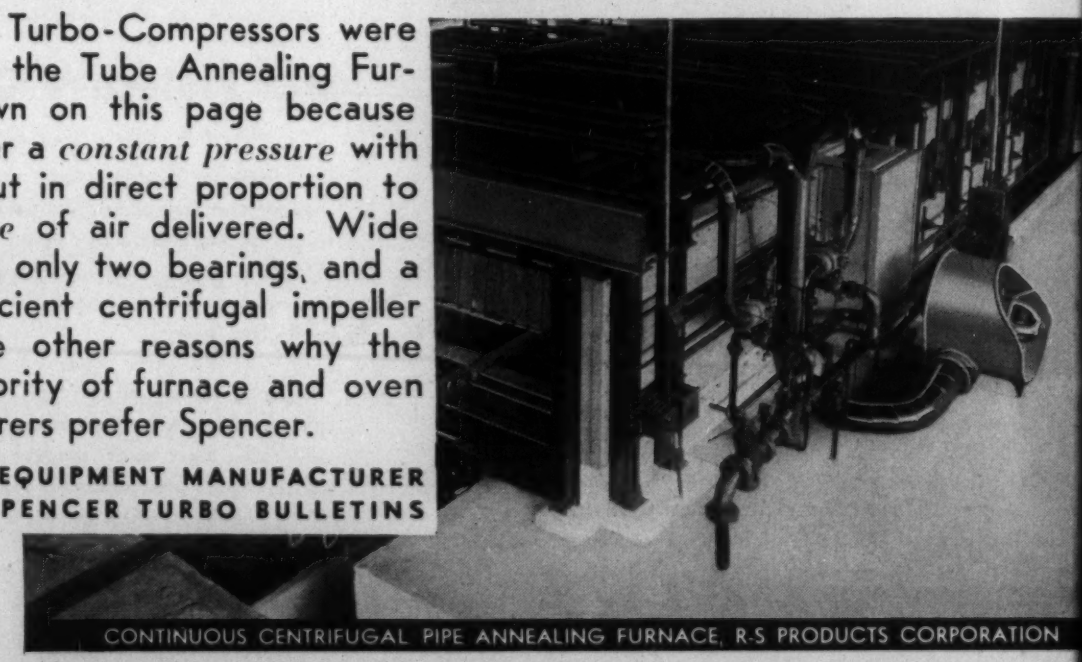
The air supply must be flexible to bring temperatures up and down according to formula, and large volumes of air must be delivered without shutdowns and with a view to the cost per foot or per ton of the finished product.

Spencer Turbo-Compressors were chosen for the Tube Annealing Furnaces shown on this page because they deliver a *constant pressure* with power input in direct proportion to the *volume* of air delivered. Wide clearances, only two bearings, and a highly efficient centrifugal impeller design are other reasons why the great majority of furnace and oven manufacturers prefer Spencer.

ASK YOUR EQUIPMENT MANUFACTURER FOR THE SPENCER TURBO BULLETINS



184-F



CONTINUOUS CENTRIFUGAL PIPE ANNEALING FURNACE, R-S PRODUCTS CORPORATION

CONTINUOUS ROLLER BOTTOM TUBE ANNEALING, PENNSYLVANIA INDUSTRIAL ENGINEERS

SPENCER HARTFORD TURBO COMPRESSORS

35 TO 20,000 CU. FT. ⅓ TO 300 H.P. 8 OZ. TO 5 LBS

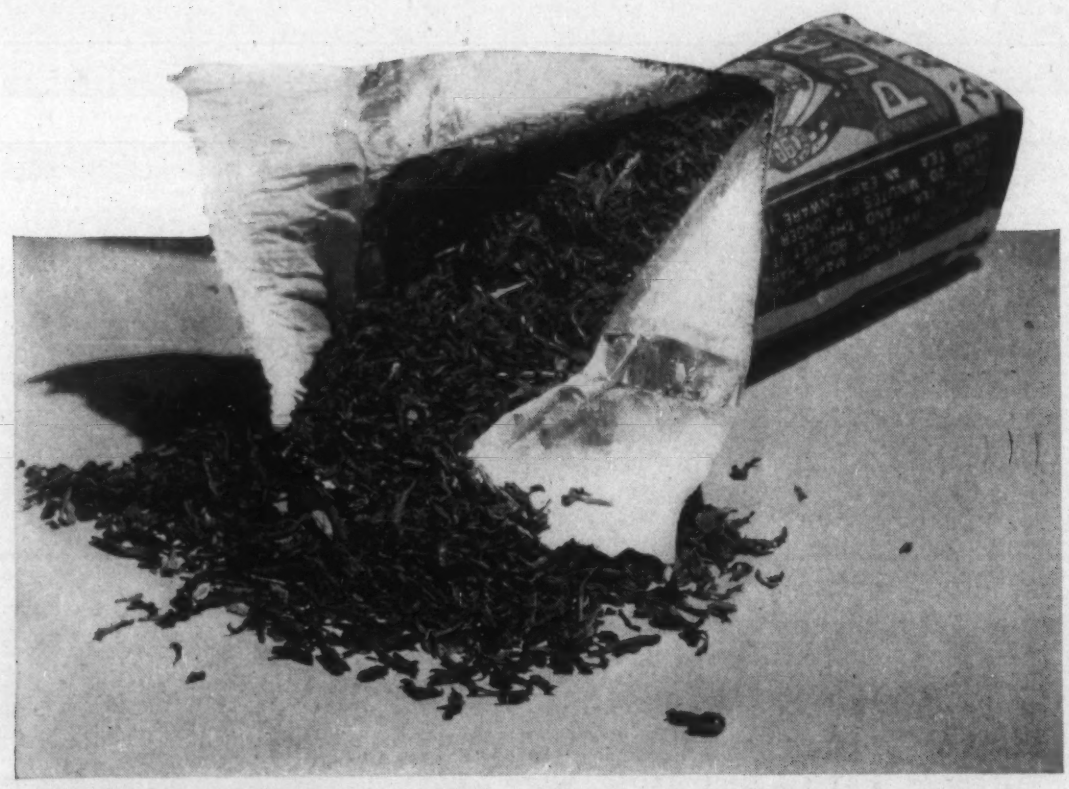
THE SPENCER TURBINE COMPANY • HARTFORD, CONNECTICUT

ton of iron; average flue-dust production was 158 lbs./net ton of iron and scrap charged was 120 lbs./net ton of iron. The theoretical desulphurizing ratios calculated from Holbrook & Joseph's curves (see METALS AND ALLOYS, Vol. 7, July 1936, p. MA 339R/7) follow the same general trend as the operating desulphurizing ratio calculated from actual analyses of slag and iron.

Increasing the MgO content to 6.5% produced no improvement in furnace practice, although silicon control was satisfactory. Desulphurizing power was lowered when total basicity was increased beyond 55%, probably because of rapid increase in slag viscosity in this region.

Lime-bearing slags of interest to the basic open hearth operator as well as the blast furnace man were studied by R. HAY & J. WHITE ("Slag Systems", *J. West Scotland Iron & Steel Inst.*, Vol. 47, 1940, pp. 87-92), although their attention was concentrated on the reducing power of the slag. A quaternary representation of the system FeO-Fe_2O_3-CaO-SiO_2 is given that holds roughly between 1650° and 1800° F., and shows how the proportions of magnetite, fayalite, olivines and orthosilicate vary with composition.

If the molecular ratio of CaO to SiO_2 is less than 2:1, some of the FeO formed during reduction will combine with SiO_2 and thus be more difficult to reduce. If the CaO/SiO_2 ratio is greater than 2, the reducibility will again be decreased by the formation of some calcium ferrite. For optimum reducibility—all other factors being neglected—the definite ratio of 2 CaO to 1 SiO_2 must be maintained. X (1a)



LEAD FOIL . . . The Ideal Protective Covering

The properties of lead—aside from its exceptional malleability — which account for its wide use in the form of foil, are its high corrosion resistance, impermeability to moisture and its resistance to the passage of light rays. That is why cigarettes, smoking tobacco, tea and many other products are protected with lead or lead and tin foil.

Strictly speaking tin foil is made of pure tin. Composition foil is often called "tin foil", while in reality it consists of about 96% lead and 4% tin. For the manufacture of composition foil, pig lead is cast into ingots weighing about 120 pounds each, and having a thickness of 1 inch. These ingots are placed between two sheets of tin, and the "sandwich" is rolled down to foil thickness, sometimes as thin as five ten-thousandths of one inch. The remarkable fact about the process is that the thickness of the tin veneer is in the same ratio to the foil as the original sheets of tin were to the lead ingot.

Uses for lead or lead alloy foil other than packaging include electrical condensers, metallic packing, tinsel, x-ray work, burglar alarm systems, caps for bottle tops and many other minor uses.

Foil is a large consumer of pig lead. As much as 39,000 tons have been used by this industry in a single year.

ST. JOSEPH LEAD COMPANY

250 PARK AVENUE · NEW YORK

ELdorado 5-3200

1b. Non-Ferrous

Centrifugal Casting

"CENTRIFUGAL CASTING." J. D. ZAISER (Ampco Metal, Inc.) *Iron Age*, Vol. 146, Aug. 8, 1940, pp. 23-28. Practical.

The centrifugal casting process was conceived in 1850 but was not commercially applied until 1900. The mechanical equipment necessary must be capable of wide speed variation (50-300 r.p.m.); hydraulic drives are recommended for speed variations, convenience of remote control of centrifugal spindles and the cushioning effect of hydraulic power.

The most common mold equipment is a steel or iron shell, dynamically balanced. The mold, usually of some kind of core sand, is rammed up in the liner and the unit baked. Only one casting can be produced because the sand liner breaks up when the casting is removed. High production steel or iron molds are machined on the inside to the desired contour. After 30-80 castings are produced in such molds, redressing is necessary.

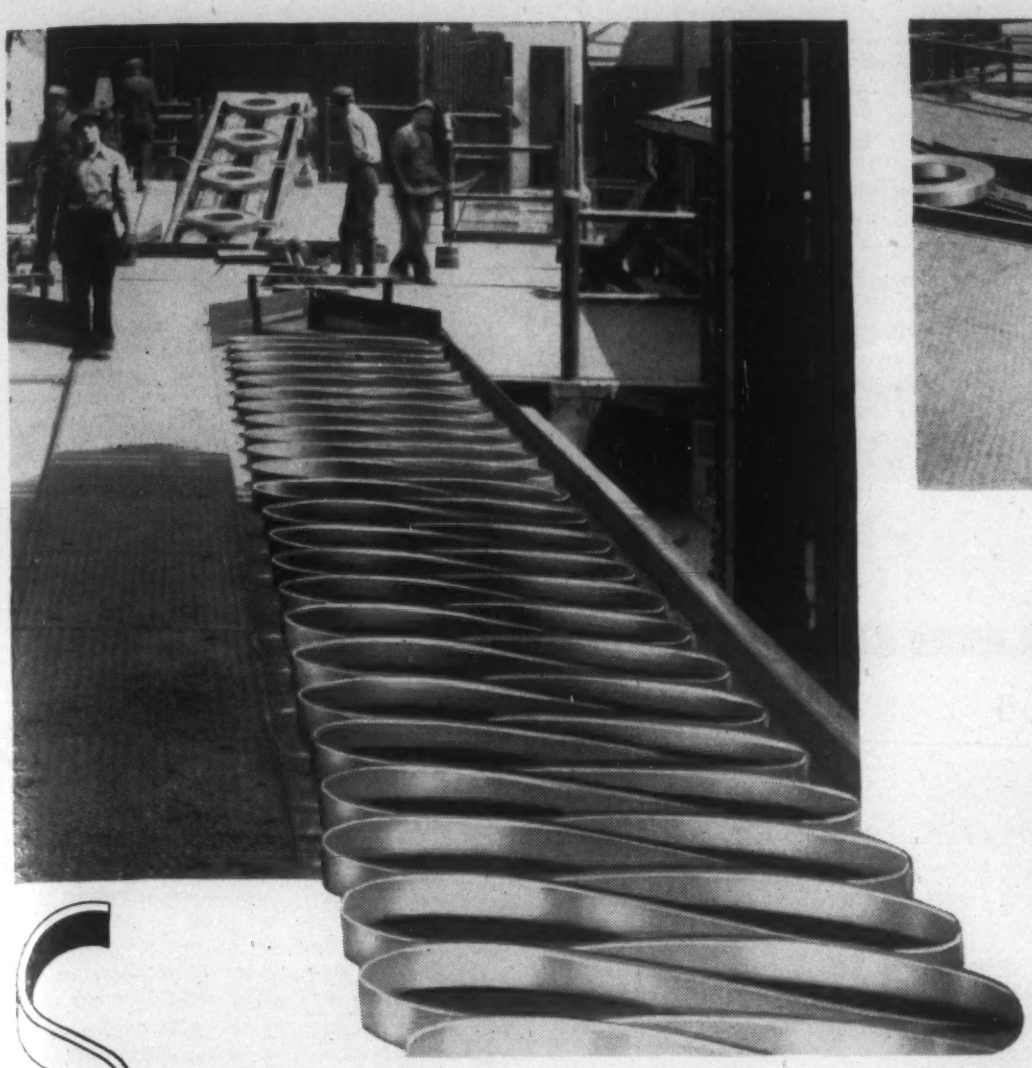
The most common method of pouring is directly in the mold through a hole in the cover plate for small pieces. For long thin-walled castings the mold is usually inclined. In another method the molten metal is either poured along the whole length of the casting by means of a trough, inserted into the mold and then dumped, or it is poured through a retracting spout that moves forward from the rear of the mold during pouring.

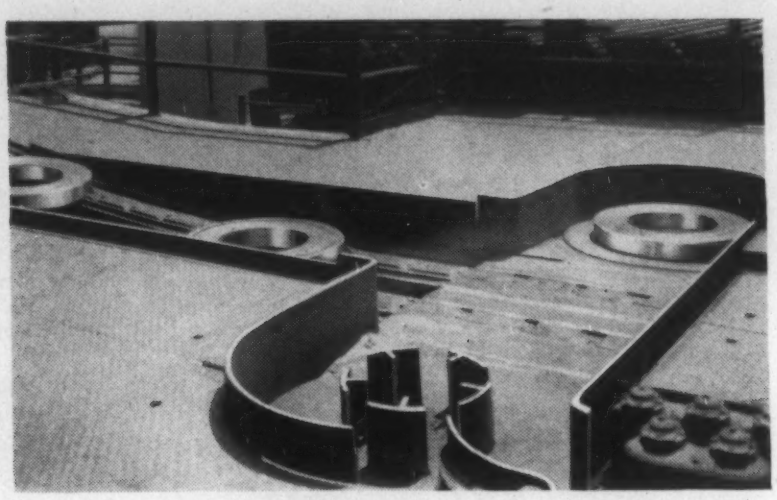
Centrifugal castings are usually made in dies or molds revolving about the horizontal axis, but the axis may be fully vertical or inclined at a desired degree to the horizontal. The speed need be just enough to hold the metal against the mold wall, although cooling, shrinkage, hot metal strength and liability to segregation must all be considered in establishing proper speeds. Plain cylinders or bushings are easiest to produce by this method. The inside diameter of the casting must be either a straight bore or one that can be machined cheaply and without metal loss.

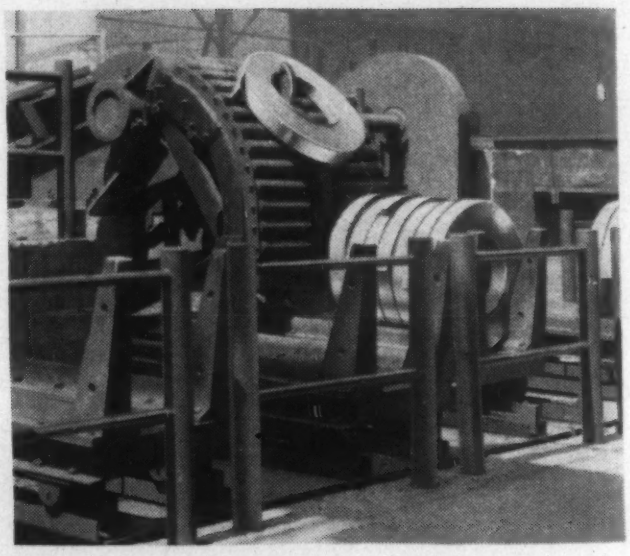
Most copper-base alloys can be cast centrifugally, although the casting practice must be varied from one alloy to another. The greatest problems are presented by "mixture alloys" such as those of the copper-lead type. They can be centrifugally cast by close attention to: (1) The chill effect so that the lead solidifies rapidly without segregation into large particles; and (2) careful speed control, well below that used for true alloys. Other alloy series that can be adapted to this process are 80-10-10 and phosphor bronze. Since tin makes this an alloy rather than a mixture high speed may be used. The main difficulty is the hot-shortness of the alloy, which tends to cause fissures or cracks unless proper control of speed, pouring temperature and chill effect is exercised.

Alloys of the aluminum bronze class are ideal for this process. The composition must be carefully watched, since aluminum is readily lost through excessive drossing caused by turbulence during casting. Manganese bronze, nickel bronze, beryllium-copper and Monel metal are adaptable to centrifugal casting.

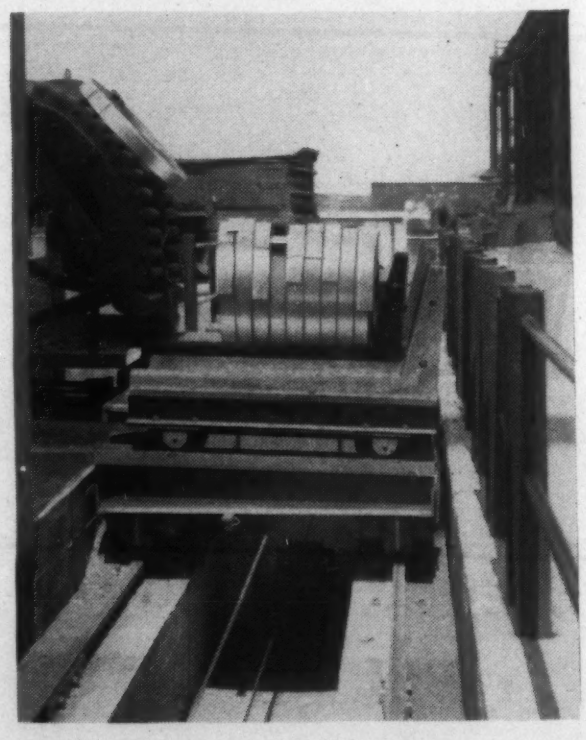
The advantages of this process are many. Metal loss during casting is very small. Gears, feed nuts and similar parts are made by this process because of the soundness of the cast material, the savings in machining costs and the minimum of defects. Most important is the uniformity of physical properties of castings. VSP (1b)







S IS FOR SKELP · · · *delivered in Coils for Continuous Weld Pipe*



A single length of pipe cannot be longer than the *Skelp* from which it is formed. Development of the Continuous Weld process, by which pipe can be turned out continuously in one unbroken length, required a drastic change in the handling of skelp. Instead of the usual cut lengths, skelp was required in coils containing some hundreds of feet.

Morgan was ready with a time-tried method. Nearly 40 years ago, Morgan developed their "candy machine." From the finishing stand skelp passes through twist guides to the Vibrator which delivers it in S formation to the slowly moving Apron Conveyor. This conveyor serves as a temporary storage between mill and reels and in effect brings the front end to rest while still receiving skelp at mill speeds.

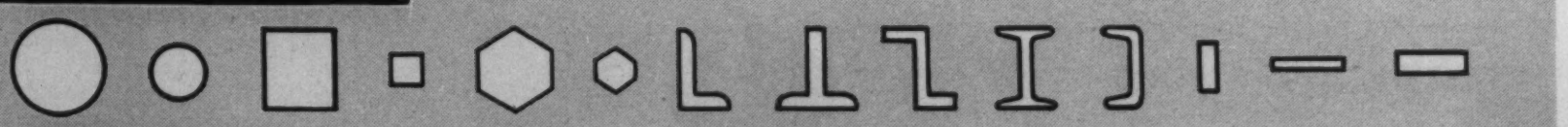
Morgan is ready—*as usual*—to meet the requirements of new manufacturing processes, which are being constantly reflected in new demands upon steel mills. Are you ready for the big demands of tomorrow's business? Why not call in Morgan—today?

MORGAN CONSTRUCTION COMPANY · WORCESTER, MASS., U. S. A.

MORGAN
WORCESTER
ENGINEERS AND
MANUFACTURERS

CONTINUOUS ROLLING MILLS

ROD · STRIP · SKELP · MERCHANT SHAPES



Producing Ductile Titanium

"The Production of Ductile Titanium." W. Kroll. *Trans. Electrochem. Soc.*, Vol. 78, 1940; Preprint No. 11, 12 pp. Research.

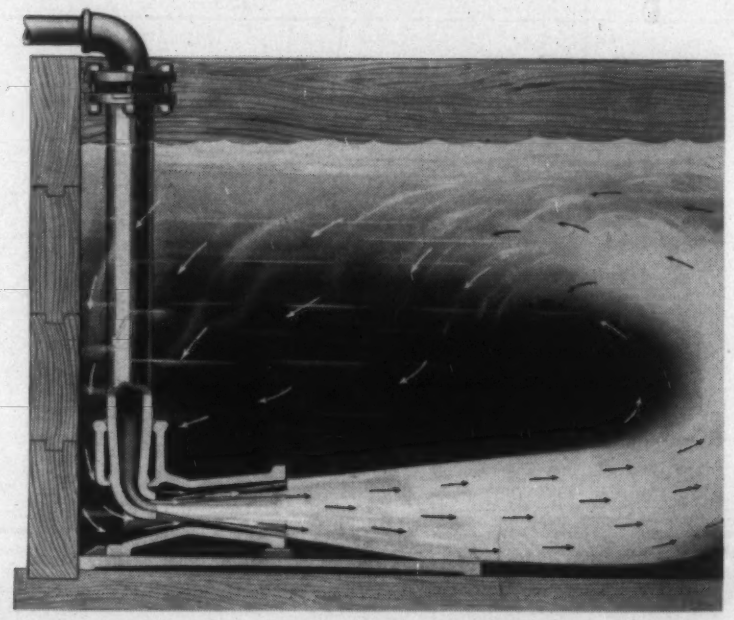
Titanium is difficult to prepare in a pure state, as it is an active metal and combines with oxygen and nitrogen, which can not be removed by heating in a vacuum. These elements cause the metal to be cold brittle but do not affect its malleability at elevated temperatures.

One method of producing titanium consists in reducing titanium tetrachloride with sodium in a steel bomb. Because of the high pressure developed, the process is suitable only for small scale production. Titanium of 98% purity can be obtained by reducing titanium oxide (TiO_2) with distilled calcium in an atmosphere of argon, at a temperature of 1800°-2200° F. Additions of calcium chloride and barium chloride aid the reduction. The product is malleable when hot but brittle when cold, because of the presence of oxygen.

The most satisfactory method of producing pure titanium (powder), consisted in reducing titanium tetrachloride with magnesium in an atmosphere of argon at 1800°-2200° F. The steel crucible was lined with molybdenum, as titanium attacks iron. There was no alloying between the magnesium and titanium. Magnesium salts were removed from the melt by leaching with hydrochloric acid. To prepare massive titanium, the powder was pressed and then melted in a furnace (with argon at 50 mm. pressure) using an arc struck between a tungsten cathode and the titanium, which served as the anode.

The metal button obtained had a purity of 99.8%. The Brinell hardness was 180-200 at room temperature and 87 at 750° F. A titanium strip less than 1 mm. thick was bent, cold, through 180° without fracture. Above 1475° F. the metal becomes brittle because of grain growth. It can be rolled, and wires were made by hot drawing through dies. Alloys of titanium with thorium, columbium, and tantalum were prepared. AB (1b)

DURIRON Steam Jets



Showing action of patented Duriron Steam Jet

heat
circulate
agitate
pickle liquors

•

dissolve salts

•

promote absorption of gases in liquids

•

This new, improved design has many features:

- **Jet nozzle is removable and replaceable.**
- **Dimensions are the same as older style Duriron Steam Jets and can be used for replacement without changing steam lines or kick-plate.**
- **Heavier wall thickness gives greater erosion resistance to the wire-drawing action of steam.**
- **Available for either bell-and-spigot or split-flanged riser pipes.**
- **Orifices of 1/4", 5/16", 3/8", 1/2", 5/8", 3/4" and 7/8".**

For direct heating of any corrosive solution. Duriron Steam Jets will heat quicker and more evenly, using steam economically, without destructive steam hammer.

Write for Bulletin No. 1801 which includes a chart for estimating number, sizes and steam consumption per hour of Steam Jets required for any size tank.

THE DURIRON COMPANY, Inc.
Dayton, Ohio, U.S.A.

Atmospheres for Melting Copper

"Effect of Atmosphere During Melting and Casting of Copper." C. R. Hayward, M. Isawa & E. M. Thomas. *J. Inst. Metals*, Vol. 66, 1940, Adv. Copy No. 869, 21 pp. Abstracted in *Chem. Abstracts*, Vol. 34, 1940, p. 6548. Research.

Commercial electrolytic copper was melted in 10-30 lb. lots in clay-graphite crucibles heated in an electric resistance furnace, exposed to various atmospheres, and cast into vertical steel molds under atmospheric control. The results showed that cathode copper melted quietly under charcoal in the absence of combustion gases or other gases (except those derived from the hot charcoal) can be cast in an atmosphere of nitrogen, hydrogen, carbon dioxide or normal illuminating gas to give a billet of high density and low oxygen content, but cannot be cast in air without giving a billet of relatively low density with an appreciable oxygen content.

The authors conclude that when the oxygen becomes low in the copper, the bath will absorb considerable quantities of hydrogen, either directly from the furnace atmosphere and the poles or through reduction of water vapor from the atmosphere and poles by hot carbon. There will be some, but considerably less, absorption of carbon monoxide, either directly from the furnace atmosphere or through reduction of carbon dioxide by hot carbon. There may be some absorption of sulphur dioxide, but most of the gas will probably be reduced to sulphur by hot carbon and from cuprous sulphide (Cu_2S). The sources of sulphur are the furnace atmosphere, the charcoal or coke, the cathode copper and the poles.

If low-oxygen copper, produced in the usual way in fuel-fired reverberatory furnaces and reduced by poling, is cast under oxidizing, reducing or neutral conditions it will always be unsound owing to the large amount of dissolved gases; the unsoundness will, however, be greater when it is cast in air, due to the formation of cuprous oxide (Cu_2O), followed by its partial reduction by hydrogen and carbon monoxide.

The principal source of hydrogen in the copper is undoubtedly the poles. It might be possible to eliminate a considerable part of it by allowing the copper to stand for a period after the poling is completed, to give time for diffusion of hydrogen from the bath to the furnace atmosphere. Decreasing the temperature would also be helpful.

Melting cathodes by continuous feeding beneath the bath in an electric furnace without poling should give a minimum of gases in the molten copper, and casting under reducing conditions in a manner similar to that used by the producers of OFHC copper should give maximum soundness and minimum oxide content. Even the small amount of air in the mold should be displaced if the best results are to be obtained. (1b)

2 Processing and Fabrication

FORGING, FORMING, MACHINING
HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting. Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Stored Energy Spot Welding

"Stored Energy Spot Welding." *Welding Engr.*, Vol. 25, Aug. 1940, pp. 19-24. Descriptive.

The high-conductivity metals like aluminum alloys require extremely high welding currents and very short timing. This had led to the application of the principle of stored energy, in either the electromagnetic or the electrostatic form, in order to eliminate excessive peak loads on the power supply mains. Aluminum alloys have a critical melting point which makes it necessary to apply welding energy to an extremely accurate degree.

The stored energy type of Sciaky spot welder employs an arrangement of pressure cylinders, welding electrodes, supporting arms and frame structures externally similar to the conventional type of spot-welder. The energy is accumulated during a period of less than a second, and the electromagnetic energy is discharged within 1/200 to 1/300 of a second.

In the Sciaky variable-pressure welder, the sequence of operations is as follows: (1) The work pieces are gripped tightly between the electrodes in order to establish good electrical contact for the welding current; (2) the pressure is decreased automatically an instant before the peak welding current, in order to obtain maximum contact resistance during the peak welding current; (3) immediately after the current peak, the pressure is increased to a value greater than the yield point of the metal being welded. This mechanical working of the metal compensates for the structural changes caused by the temperature rise during welding.

All these operations are accomplished automatically. In the welding of stainless steel or ordinary mild carbon steel, the pressure control is changed so that welding is accomplished under constant pressure.

In the Sciaky system the welding transformer acts not only as a transformer, with primary and secondary windings, but also as an iron-cored choke. It is charged with direct current, usually supplied by a mercury arc rectifier operating from a three-phase alternating current power supply. The principle of the Sciaky welder is such that the welding current is not affected by any fluctuations of line voltage.

All electrodes used in welding aluminum and its alloys should be made from hard drawn electrolytic copper. Any gain in hardness produced by alloying other elements with copper is more than offset by the loss in thermal and electrical conductivity.

The d.c. to charge the transformer of the Sciaky welder is normally supplied by a mercury arc rectifier capable of a peak output of 400 amps. at 110 v. The line supply required is three-phase a.c. at 220 v. The power required by the Sciaky welder is approximately 1/10 of that required by a.c. machines. CEJ (2)

The Friction Factor in Machining

"Chip Formation, Friction and High Quality Machined Surfaces." H. Ernst & M. E. Merchant. *Preprint, Am. Soc. Metals*, Oct. 1940, 38 pp. Research.

Previous investigations on the process of metal cutting have thrown considerable light on the mechanism of chip formation, and have shown that the built-up edge is the major cause of roughness on finished surfaces.

This paper presents a further step in this development, and sets forth the beginning of a quantitative treatment of the metal-cutting process. An extremely high value of coefficient of friction between chip and tool usually exists in cutting, and this is responsible for the existence of a built-up edge (with its accompanying surface roughness) and also for the poor efficiency of metal removal that is characteristic of all our present-day metal-cutting processes.

A theoretical and experimental study of friction shows that the hardness of mating metal surfaces and the resistance to shear at their areas of actual contact are the variables of greatest importance in dry friction. For ordinary dry metal surfaces in contact, resistance to shear is low, because of the presence of strongly adsorbed films of low-shear-strength materials, which always cover

BEAT THAT RUST PROBLEM—

with these new, proven rust preventives

★

A complete line of rust preventives, recently re-evaluated because of the increasing need for protection of iron and steel so imperative in the National Defense Program.

Houghton, a maker of rust preventive coatings since 1869, now announces a new program including 14 standard varieties of

RUST VETO

Every needed type of film - fluid, non-drying, grease, hard-drying and soluble - is included. For the new fluid Rust Veto a base product has been developed that has proved to be as much as 150% more effective than former preventives, based on the time before rust appeared on test specimens.

There are types to meet government and manufacturing specifications. Get the new Rust Veto story by writing for leaflet just off the press.

★

E. F. HOUGHTON & CO.
3rd & Somerset Sts.
PHILADELPHIA
Chicago — Detroit

1865 1940 75 years The HOUGHTON LINE

such surfaces. When, under unusual conditions, these films are practically absent, the coefficient of friction rises to very high values because the opposing metal surfaces have united at their points of contact, and thus the metal itself must be sheared.

From the evidence presented, it is apparent that great advances in the field of metal cutting may yet be made if cutting fluids can be developed that will provide and maintain low-shear-strength material at the chip-tool interface, even at very high cutting speeds. (2)

2a. Ferrous

Tubular Normalizing Furnace

"A Tubular Furnace." John H. Loux (Salem Eng. Co.) *Steel*, Vol. 107, Aug. 5, 1940, pp. 54, 56. Descriptive.

A new and improved type of tubular furnace used for normalizing up to 1750° F. and for drawing at as low as 800° F. can handle steel pipe 2-14 in. in diam. The same close temperature uniformity is held at both the lower and the higher temperatures. A driven roller hearth is used and all bearings are air-cooled.

The furnace is a horizontal cylinder, whose shell requires no buckstays yet has superior strength. Burners are placed both above and below the alloy rollers and fire tangentially into the chamber. The swirling action of the gases is responsible for the excellent uniformity during drawing. The lower burners fire into a specially-designed combustion-chamber that protects the rollers from direct flame impingement and prevents localized heating of material passing through the furnace.

Heating rates have been considerably increased over former practice. Natural-gas consumption is 750 ft.^{3}/ton when normalizing and much less when drawing. The heating chamber is a little over 100 ft. long. The lining consists of a lightweight refractory material, backed up with high-grade insulation. The furnace may be raised from draw temperature to normalizing temperature in 1 hr. and may be lowered from normalizing temperature to draw temperature in 2 hrs. It heats about 20 tons/hr. when normalizing and about 18 tons/hr. when drawing.

There are 2 zones of automatic temperature control. Each zone is equipped with an automatic air-gas ratio controller, which can be set for any type of atmosphere desired. At 2 points along the length of the heating chamber, adjustable dampers are provided so a definite temperature difference can be maintained on each side of these points for special annealing work. Special hard-burned brick are used for a short distance above the rollers to prevent gouging should a pipe happen to work out of line on roller hearth. A "Rayotube" pyrometer is used at the discharge end to measure and record the temperature of the tubes. If the tubes are kept at least 6 in. away from furnace walls, a highly satisfactory degree of uniformity is maintained from the center tubes to those on the extreme outside. MS (2a)

Annealing Gray Iron

"Decomposition of Pearlite in Grey Cast Iron." A. A. Timmins. *Foundry Trade J.*, Vol. 63, Aug. 15, 1940, pp. 109-110; Aug. 22, 1940, pp. 121-123. Review plus research.

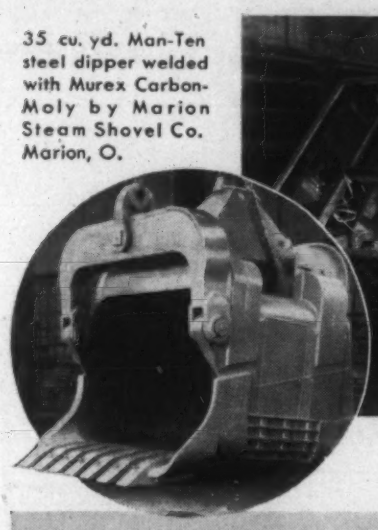
The annealing of gray iron involving the decomposition of pearlite may be readily accomplished at temperatures *below* the critical point. In such cases the rate of cooling after heating is of little importance, while the time occupied at the soaking temperature is of the greatest importance in removing pearlite. The nearer the heating temperature is to the critical point of the iron, the more rapid is the removal of the combined carbon.

When the annealing is carried out at a temperature *above* the critical point, however, a different condition arises. In this case, the time of soaking plays little part in the removal of the pearlite, but the rate of cooling after soaking is of major importance; the slower the rate of cooling, the greater is the amount of pearlite decomposed. Above the critical point, combined carbon may or may not be removed according to whether the initial combined carbon content is above or below the equilibrium content for the temperature of the anneal. Thus, if the combined carbon is high, it will tend to fall to the equilibrium content as heating is prolonged, while it will tend to rise to the equilibrium content if it is low in the as-cast bar.

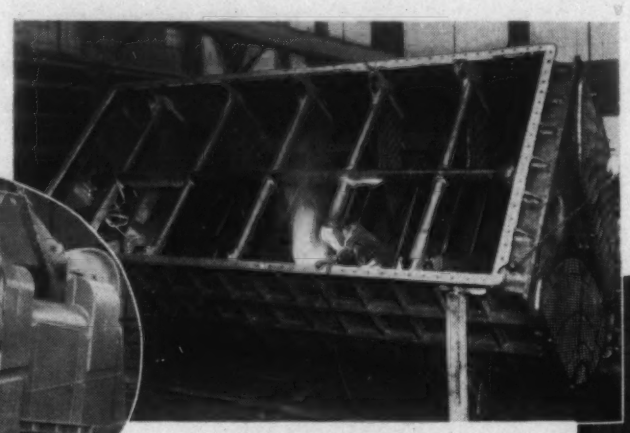
The removal of combined carbon in gray cast iron is in proportion to the square root of the time of heating, which confirms the suggestion made by Schwartz and others that graphitization is a diffusion phenomenon and follows laws similar to those governing the diffusion of solids in liquids.

Silicon does not appear to affect the rate of graphitization at constant temperature. However, combined carbon content in high-silicon irons is usually lower than for lower-silicon cast irons. The critical point is raised and the solubility of carbon decreased by an increase of silicon, which means that for a given temperature more pearlite may be removed than with an iron of lower silicon content.

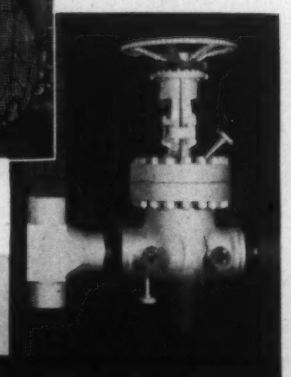
The results obtained have a great bearing on the commercial annealing of gray cast iron. The most important fact is that



35 cu. yd. Man-Ten steel dipper welded with Murex Carbon-Moly by Marion Steam Shovel Co. Marion, O.



Murex-welded shell and turbine connector built by Ross Heater & Mfg. Co Buffalo.



High pressure piping welded with Murex Carbon-Moly by Geo. C. Limbert & Co., Chicago.

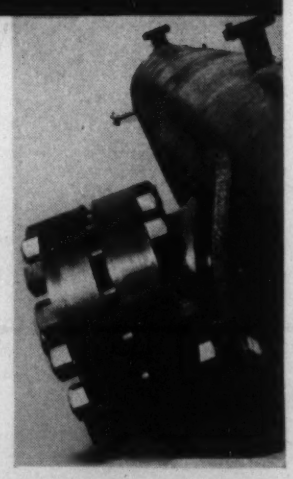
SPEED UP YOUR WELDING OF HIGH STRENGTH—LOW ALLOYS WITH

MUREX ELECTRODES

SPECIALLY DESIGNED FOR CARBON-MOLY, COR-TEN, MAYARI, CROMANSIL, 2%-3% NICKEL AND OTHER STEELS

- The Murex line includes a group of specially developed rods designed to produce welds with tensile strengths ranging from 70,000 to 100,000 lbs. per sq. in.; ductilities of 20% to 30% and corrosion and heat resisting qualities matching closely any of the more widely used new steels. Because of their excellent deposition rates at high amperages, their ease of handling by skilled welders, and the assurance they provide of cleaner, smoother deposits they step up welding speeds and help hold down costs.

Ask to have Murex Electrodes demonstrated on your high strength—low alloy applications. A note to the nearest M & T office will bring a representative promptly.



Accumulator built of A. S. T. M. A-203, Grade B steel by Black, Sivalls & Bryson, Oklahoma City. Welded with Murex Nickel Steel.

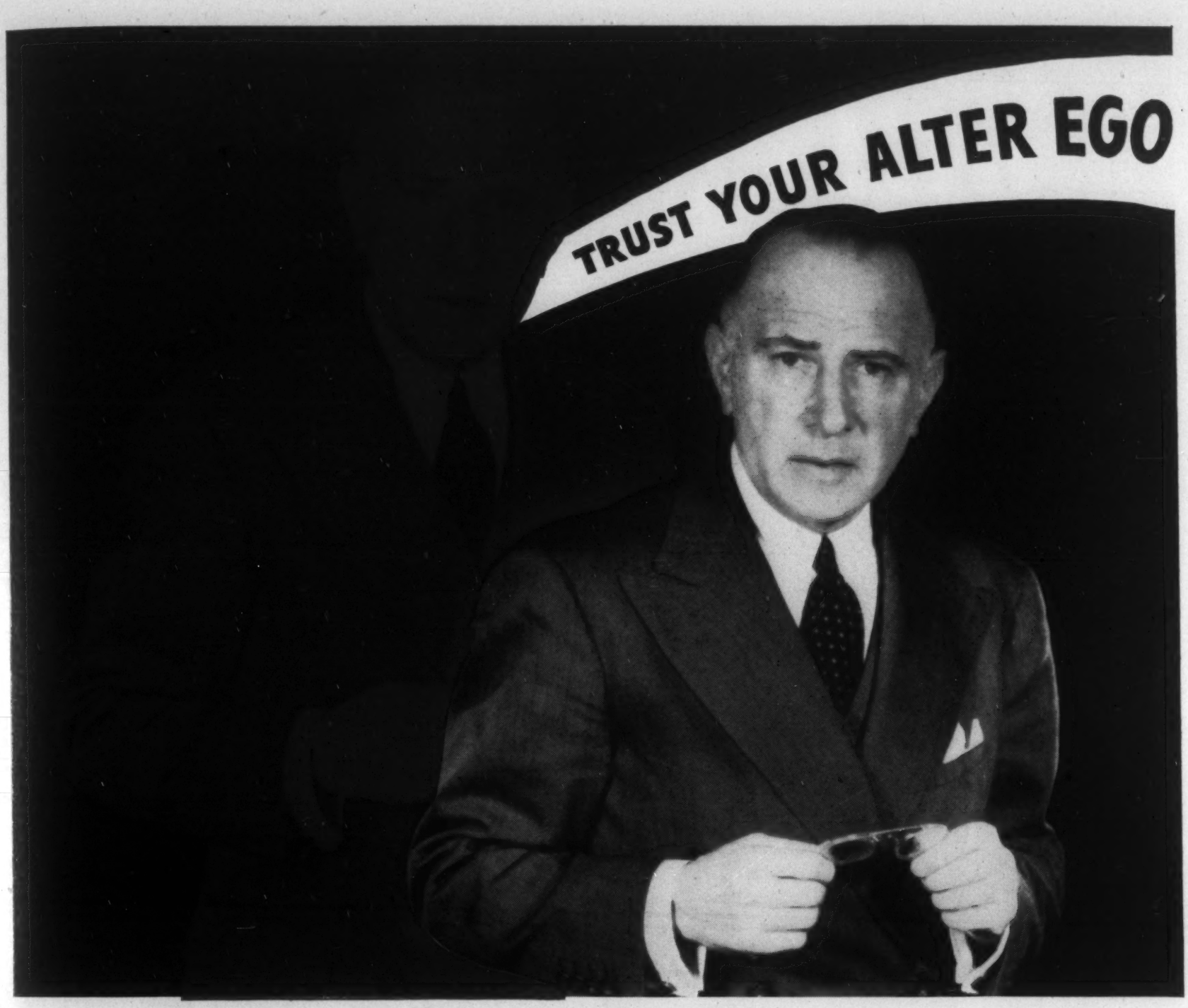
METAL & THERMIT CORPORATION
120 BROADWAY, NEW YORK, N. Y.

Albany • Chicago • Cincinnati • Detroit • Minneapolis • Pittsburgh
So. San Francisco • Toronto

"Murex Electrodes—Thermit Welding—Thermit Metal & Alloys"

Investigate Thermit Welding, too—in use since 1902 for heavy repair work; crankshafts, housings, frames, etc.

MUREX HEAVY COATED Electrodes
A COMPLETE LINE FOR EVERY WELDING APPLICATION



ALTER EGO: Literally "one's other self"—the still, small voice that questions, inspires and corrects our conscious action.

ALTER EGO: Let's talk things over. As your other self, I feel it my duty to give you some advice on how to improve your product and cut its cost.

Well, you're one fellow I don't mind getting advice from. I know you *won't try to sell me something.*

ALTER EGO: All right. Here's my suggestion. First, improve your reasoning technique. Learn to *trust your Alter Ego*. Listen to that inner voice more often.

All right, but I've had to use my conscious mind so much to ward off exposure to arc welding salesmen that I've got in the habit of trusting my surface judgment.

ALTER EGO: Yes, and because of surface reasoning you're too prone to deride that which you don't sufficiently understand. Look how others are profiting with arc welding.

But how can I understand arc welding without opening up to sales exposure?

ALTER EGO: I understand that Lincoln is a good source for arc welding information that's devoid of your pet aversion. Not a high-pressure sales talk in a book-full.

• •

LINCOLN SUGGESTS: To acquaint yourself with arc welding, why not obtain a factual, informative discussion of this metal working process—as applied to your problems? Lincoln has a series of bulletins on Design for Welding which suggests how to change over to arc welding for improved products, lower costs and faster production. Why not write for them?

LINCOLN "SHIELD-ARC" WELDING THE LINCOLN ELECTRIC COMPANY Cleveland, Ohio

Authoritative Information on Design • Production • Welding Equipment

softening can be obtained most easily and more completely by annealing at temperatures near the critical point of the iron concerned. If higher temperatures are employed, very slow cooling is necessary in order to remove all the pearlite and obtain maximum softness. AIK (2a)

Shrinkage Stresses in Welds

A Composite

The problems introduced by shrinkage stresses in welded structures are of the greatest practical interest to the designing engineer as well as to the man in charge of the welding operation itself. These problems are complicated, and involve technique, assembly-design, amount of "fastening" during welding and cooling, etc.

Data obtained in a Belgian Welding Committee research on the subject are reported by D. ROSENTHAL & J ZABRS ("Temperature Distribution and Shrinkage Stresses in Arc Welding," *Welding J., N. Y.*, Vol. 19, Sept. 1940, pp. 323s-331s). To simplify the problems of the control of variables, studies were made on flat plates with weld metal deposited along one edge.

The maximum temperature attained at every point of the plate depend on two factors only: (1) The arc energy, and (2) the speed of advance of the electrode. When these are constant the isothermal contours in the plate are parallel to the weld except near the start and conclusion of the weld. Stresses in the plate normal to the weld are negligible for this case and longitudinal stresses are those computed from the data on length changes. Two zones were found in the specimen plates, one of plastic deformation close to the weld and farther away the zone of elastic deformation.

The stress on the edge opposite the weld increases approximately in proportion to the arc energy in watts. The speed of advance of the electrode, however, (within the limits of customary manual welding) has no appreciable effect on shrinkage stress. Deflection-time graphs give the progressive changes taking place while heat is being added to the plate from the arc and during the cooling period. From 4 to 7 min. are required for maximum (constant) deflection opposite in sign to that established during 1 to 2 min. initial interval for a series of plates welded with differing arc energies.

The design phases of the problem are examined by LAMOTTE GROVER of Air Reduction Sales Co. ("Butt-Welded Beam and Girder Splices and Control of Shrinkage Stresses," *Ibid.*, pp. 654-658). The structure should be so assembled that while the heated metal at the point of welding is cooling and shrinking all other parts of the members or assembly can either move, shrink or deform enough to prevent the shrinkage of the heated metal from setting up excessive internal stresses. In most cases of welded construction, this can be accomplished by proper design and detailing of the parts, careful preparation and fit-up of material, and a proper sequence of welding.

With respect to the effect of multi-axial stresses, for ductile material like mild structural carbon steel any such stresses in a tension member are largely relieved through local deformation. This is proved by the case of large rolled beams that are known to be loaded with multi-axial stresses when they leave the mill but still give entire satisfaction in service. The most serious effect of multi-axial stresses are thought to be largely on small or reduced areas in the welded joint to which shrinkage is confined while the metal is cooling from welding temperature.

It would therefore appear that once the welding for a ductile steel structure has been successfully completed and all the welds have cooled down and adjusted to service conditions with no existing cracks, fissures or other serious defect, then there is nothing to fear from shrinkage stresses. WB (2a)

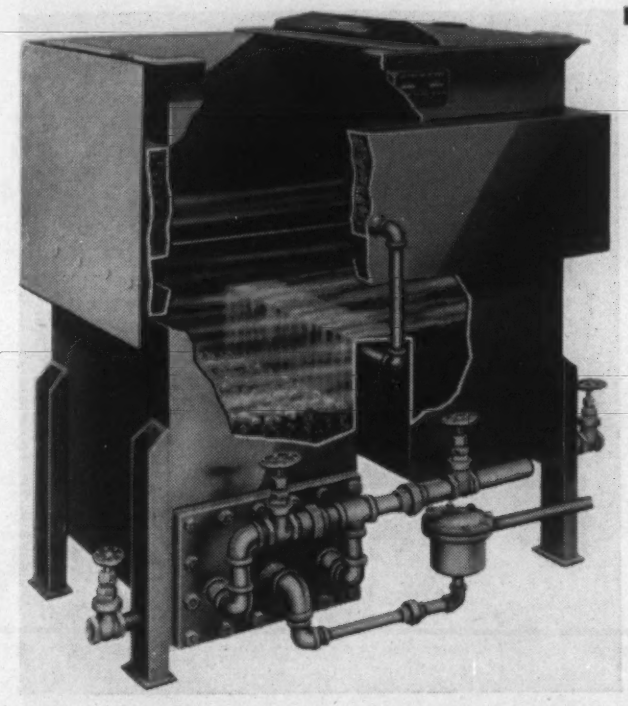
Flame Cleaning Structural Steel

A Composite

The preparation of structural steel surfaces for painting by oxyacetylene flame cleaning is a relatively young process. Its greatest appeal is said to be its better suitability for structural fabrication than sand blasting, chemical cleaning or mechanical cleaning. Its real value in increasing the service life of paint coatings has yet to be determined.

These are some of the comments made by F. H. DILL of American Bridge Co. ("Flame Cleaning of Structural Steel," *Paper, Am. Welding Soc.*, Oct. 1940 meeting) in a practical review of the process. Flame cleaning uses relatively simple equipment, but permits the priming coat to be applied on surfaces that are warm, dry and free of rust and unbonded mill scale. The process, however, is a fairly expensive operation and is by no means a panacea for all structural painting problems.

Flame cleaning, which requires intense, high-temperature flames to be traversed over the surfaces to be cleaned at a speed of about 30 ft./min., has a "lifting action" that tends to raise the exposed edges of



Try
DETREX
DEGREASING
FREE
On Your
DEFENSE
ORDERS

YOU can use a hand-operated degreaser while you are determining your production needs. You will see the speed, economy and efficiency of this improved cleaning process.

Detrex equipment and materials meet your present-day requirements for Solvent Degreasing . . . Alkali, Spirits and Emulsion Cleaning . . . Bonderizing, Painting and Baking. Write for complete information.

DETROIT REX PRODUCTS COMPANY

13014 Hillview Avenue • Detroit, Michigan

Branch Offices in Principal Cities of U. S. A.

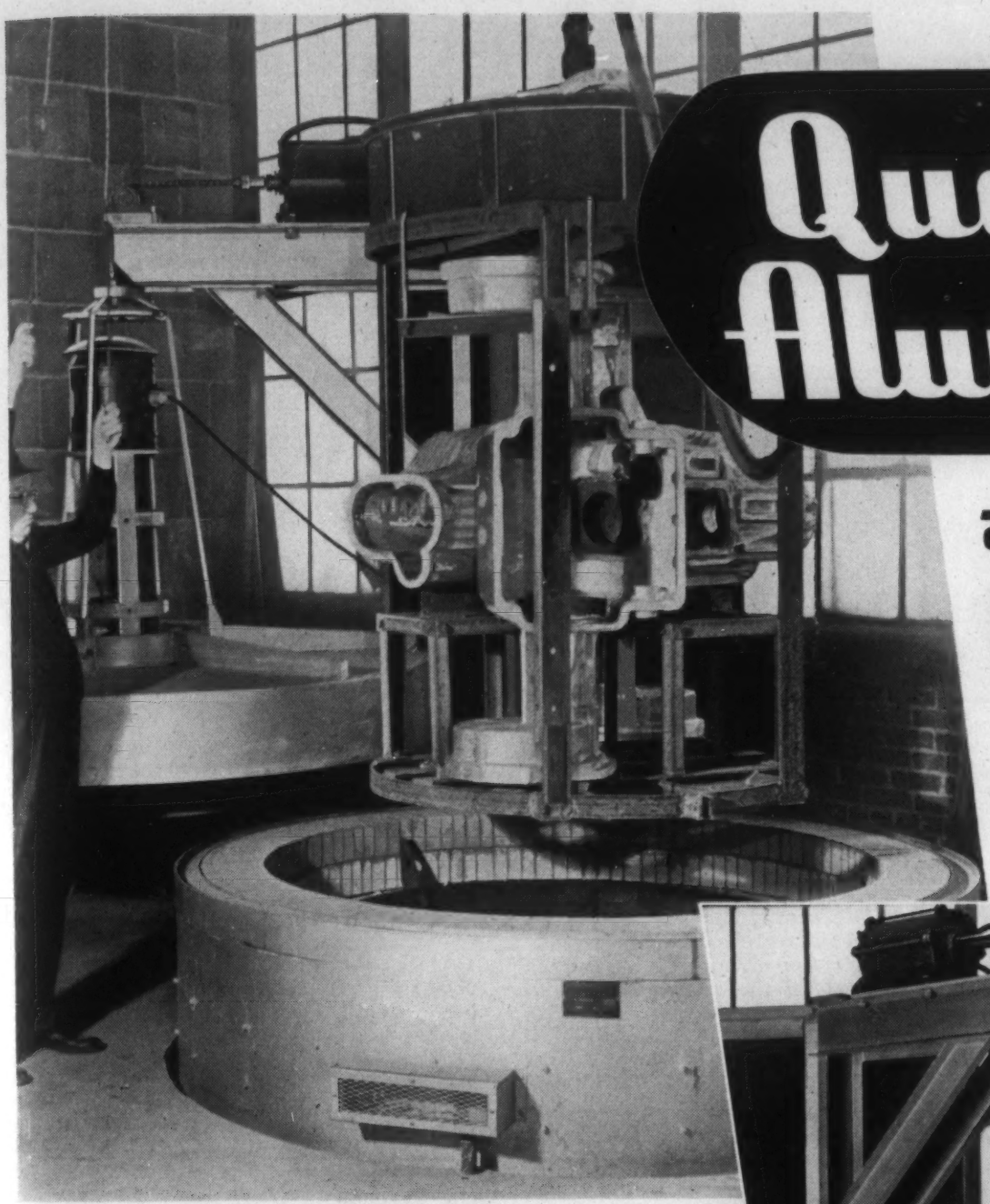
In Canada—Canadian Hanson & Van Winkle Company Ltd., Toronto, Ont.

METAL CLEANING ENGINEERS • SOLVENT DEGREASING AND ALKALI CLEANING

Quality Aluminum

and

HEVI DUTY FURNACES



An HD 6084 Pit Type Furnace at the Quality Aluminum Casting Company, Waukesha, Wisconsin

To insure accuracy in their heat treatment of aluminum alloy castings and to develope the maximum physical properties of the metal thru a controlled heat treating cycle, the QUALITY ALUMINUM CASTING CO. of Waukesha use a Hevi Duty Pit Type Furnace.

Send for Hevi Duty Furnace Bulletins

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY

MILWAUKEE, WISCONSIN

scale and effect the removal of any that is not tightly bonded to the steel. The application of the flames is followed by thorough wire-brushing to break away any partially-freed scale, dirt or rust. The surface is then swept to remove the fine dust which remains from the previous operations, leaving it clean, dry and warm for painting.

The experimental use of acetylene, propane and hydrogen has shown that high flame intensity—the ability to heat quickly—is most essential for flame cleaning. High flame jet velocity and, to a lesser degree, high flame temperature are simple indices of high flame intensity. Recent specifications require that "oxyacetylene flames having an oxygen to acetylene ratio of at least one and a ratio of inner cone length to flame port diameter of at least eight" shall be used for flame cleaning. The individual flames of the burner should be not more than 0.15 in. center to center and the number, arrangement and manipulation of the flames should be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.

The importance of the dehydrating function of oxyacetylene flame cleaning is stressed by J. G. MAGRATH of Air Reduction Sales Co. ("Flame Pretreatment of Structural Steel Surfaces for Painting," *Paper, Am. Soc. Metals*, Oct. 1940, 14 pp.). Structural steel that has been exposed to the atmosphere for the normal time between rolling and painting is usually oxidized somewhat. If painted at this stage without dehydration and conditioning, the moisture sealed within results in an imperfect paint bond.

In flame treatment, the multi-flame tip quickly heats the scale, which cracks off as a result of differential expansion and of the conversion to steam of scale-entrapped moisture. Flame cleaning should always be preceded by a preliminary solvent cleaning to remove oil and grease. For repainting, it is essential to remove all loose paint, mill scale and rust before attempting either total or spot repainting.

To date, more than 100,000 tons of bridge steel has been flame-cleaned and dehydrated with encouraging results. The process also fills a need in the maintenance field on erected steel structures exposed to the atmosphere. The disintegrating ability of the high-temperature oxyacetylene flame, as a surface conditioner, has not been fully explored, and is already carrying the flame-treating process to applications beyond the simple removal of paint and oxides from structural steel.

FPP (2a)

Induction Heat Treating

A Composite

One of the most notable metallurgical engineering trends of recent years is the rapid perfection and spreading use of the process of induction heating. Not only steels, but cast irons of certain types are being hardened in this way, and the heating is often done for tempering, forging, etc., as well as for hardening. Also, engineers successfully induction-heat entire sections or inside surfaces in addition to the more familiar exterior surface treatment.

In fact, the obvious advantages of the process would have been more rapidly adopted and its present use would be even more widespread if the *surface*-heating aspects had been less emphasized, claims EDMUND BLASKO of Ford Motor Co. ("Heat Treating with Induction Heat," *Preprint, Am. Soc. Metals*, Oct. 1940, 19 pp.). Heating parts in their full cross-section opens a wide field for induction heating—lower-frequency generators of smaller size may be used, with consequently lower installation costs than for surface heating. Heating the parts in their full cross-section develops more desirable physical properties, it is said.

After considerable experimentation, the Ford company now heat-treats many parts in selected sections (but completely across the section) using frequencies as low as 960, 1920 and 60 cycles; parts are heated fully across the section in 10-45 sec. Most of the heating coils are of round copper tubing with multiple layers, either in their full length or at the ends, to increase the strength of magnetic fields at those places.

Full-section induction heating can be done more slowly than surface heating, and thus permits a smaller electrical input at lower frequencies, with less expensive generators. Full-section-heated parts also cool slowly, and therefore do not have to be quenched immediately with automatic follow-up quenching devices, but can be removed from the heating coil for quenching. Time-cycle control need not be super-precise nor complicated. Combination heating-and-quenching equipment is said to be justified only when surface heating is essential, when large awkward parts like crankshafts are being handled, when it increases production, or when it produces a better article.

One of several parts hardened by high-frequency induction is the Ford driveshaft. 1⅛ in. diam. and 6 ft. long, made of 0.35% C steel. The center bearing, the end bearing and the end to be splined are hardened. Two sections of the vertically-held

Electric
and
Fuel Fired
Furnaces

ELECTRIC FURNACES FUEL FIRED

We Build
The Furnace
to Fit
The Job

Production Furnaces

For Forging, Annealing, Hardening, Brazing, Nitriding

or Any Other

Heating or Treating Process

We build furnaces for any product, process or production. Our large and experienced engineering staff and ample manufacturing facilities enable us to make reasonably prompt deliveries.

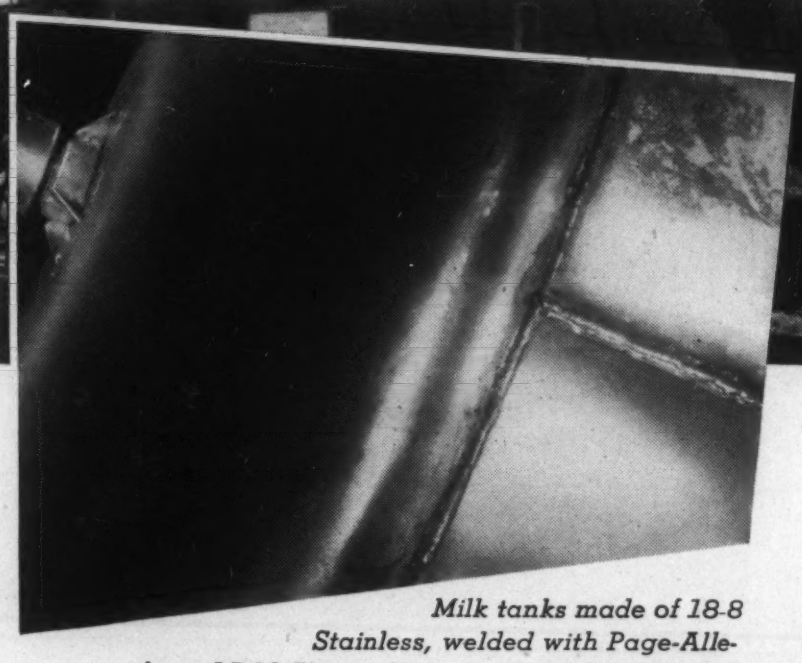
We Solicit Your Furnace Inquiries.—Fuel Fired or Electric

The Electric Furnace Co., Salem, Ohio

Page-Allegheny Stainless Steel Electrodes

BETTER WELDS—LOWER WELDING COSTS FOR ALL STAINLESS STEEL WELDING

Slasher Cylinder for textile industry. Made of 28-30 Stainless. Welded with Page-Allegheny Type 446, 23-30%—Chromium Electrodes.



Milk tanks made of 18-8 Stainless, welded with Page-Allegheny 25-12 Electrodes to insure high resistance to corrosion without the need for stabilization.

There is one electrode that is suited best to whatever of the many combinations of stainless steel you want to weld. • And you can bank on finding that one best electrode in the Page-Allegheny group—developed by Page in conjunction with the largest tonnage producer of Stainless Steel. • All of these Page-Allegheny Electrodes are suitable for flat, vertical or overhead welding. • All have a uniform, heavy flux coating. • When the recommended electrode is used, the weld metal in welds has the same physical and chemical properties as the metal being welded. • You will find it worth while to get welding electrode recommendations from your local Page Distributor. You get better welds at lower welding cost.

PAGE STEEL AND WIRE DIVISION • MONESSEN • PENNSYLVANIA

AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION	HAZARD WIRE ROPE DIVISION	READING-PRATT & CADY DIVISION	*In Canada:* DOMINION CHAIN COMPANY, LTD.
AMERICAN CABLE DIVISION	MANLEY MANUFACTURING DIVISION	READING STEEL CASTING DIVISION	*In England:* BRITISH WIRE PRODUCTS, LTD.
ANDREW C. CAMPBELL DIVISION	OWEN SILENT SPRING COMPANY, INC.	WRIGHT MANUFACTURING DIVISION	THE PARSONS CHAIN COMPANY, LTD.
FORD CHAIN BLOCK DIVISION	PAGE STEEL AND WIRE DIVISION	•	

shaft, 2.5 and 6.5 in. long, respectively, are 3 ft. apart but are heated simultaneously in 2 induction coils held in a supporting fixture. After heating, the shaft is removed from the fixture and quenched vertically in caustic soda solution.

Heating time is 12 sec., sufficient to heat the stock fully across the section; the surface hardness is 54-62 Rockwell C, with core hardness 40-45 Rockwell C. The generator used is a 50-kw., 960-cycle, 240-v., 1800-r.p.m. unit driven by a 100-hp. motor.

After hardening, 3.5-in. lengths of the hardened shafts are tempered to permit cutting the splines and for the tempering operation the same 960 cycle current is passed through 6 drawing coils connected in series. The shaft ends are heated in 48 sec. to about 1200° F. Many other applications of induction heating are described.

Induction hardening offers certain newly-recognized structural advantages over conventional heating, and these are examined by M. A. TRAN & H. B. OSBORN, JR. of Park Drop Forge Co. and Tocco Div., Ohio Crankshaft Co., respectively ("Inherent Characteristics of Induction Hardening," *Preprint, Am. Soc. Metals*, Oct. 1940, 21 pp.). Complete carbide solution has been accomplished by induction heating in only 0.2 sec., and carbide diffusion in a pearlitic structure becomes essentially complete within the grain before any appreciable diffusion into the ferrite boundaries is discernible.

Induction heating produces a finer, more homogeneous and more thoroughly dispersed austenite than conventional heating, resulting in a quenched martensite of these same characteristics. The resulting final hardness may be 2-6 pts. Rockwell C higher. The structure of an induction-hardened area is characteristic in appearance, the acicular martensite resulting from furnace hardening being replaced by a nodular, finer martensite. (2a)

Guaranteed 99.99+% Pure

WHEN you choose Anaconda Electric for the base of Zinc die castings, you are certain of obtaining uniform, dependable metal. For every slab of Anaconda Electric Zinc is electrolytically refined and guaranteed 99.99+% pure.

Anaconda Electric Zinc is supplied in 50 lb. slabs clearly marked "Anaconda Electric 99.99+%." Whenever you use this well-known brand, whether in small quantities or carload lots, you may be sure that *every slab will test 99.99+% pure.*

89392

Shipping Point: Great Falls or Anaconda, Montana

ANACONDA
from mine to consumer

ANACONDA SALES COMPANY
25 Broadway, New York
Subsidiary of Anaconda Copper Mining Company

Welding Cast Iron

A Composite

The welding of cast iron is an operation that challenges both engineering knowledge and welding skill. Many welders have secret techniques and very special electrodes or rods whose details (fortunately, perhaps) remain their exclusive possession to the grave. Yet cast iron is being welded regularly, not only in repair work but for some original construction as well. Successful welding of cast iron seems to depend on treating the job as a metallurgical engineering problem (since much of the trouble results from its complex structure), providing thermal control such that residual stresses and excessive weld hardening are avoided, and using filler metal appropriate for the job on hand.

Bronze Welding

Bronze, mild steel and cast iron welding rod have all been successfully used. According to L. TIBBENHAM ("Welding of Cast Iron," *Foundry Trade J.*, Vol. 62, May 23, 1940, pp. 377-378) the great advantage of bronze welding of castings is that the temperatures reached are not high enough to cause the iron to transform. The operation is neither fusion welding nor brazing, but definite surface alloying. The bronze is added as a bronze rod in conjunction with the oxyacetylene flame.

Joints equal in strength and reliability to a fusion weld can be made by this process with very little preheating. If the article is very large, local heat should probably be applied adjacent to the weld. The veed faces are heated to a dull red to remove graphite flakes, and welding itself is carried out at a medium red heat. Too high a temperature causes the bronze globules to run off the metal, and too low will hamper tinning. Most welders use too large a blowpipe tip.

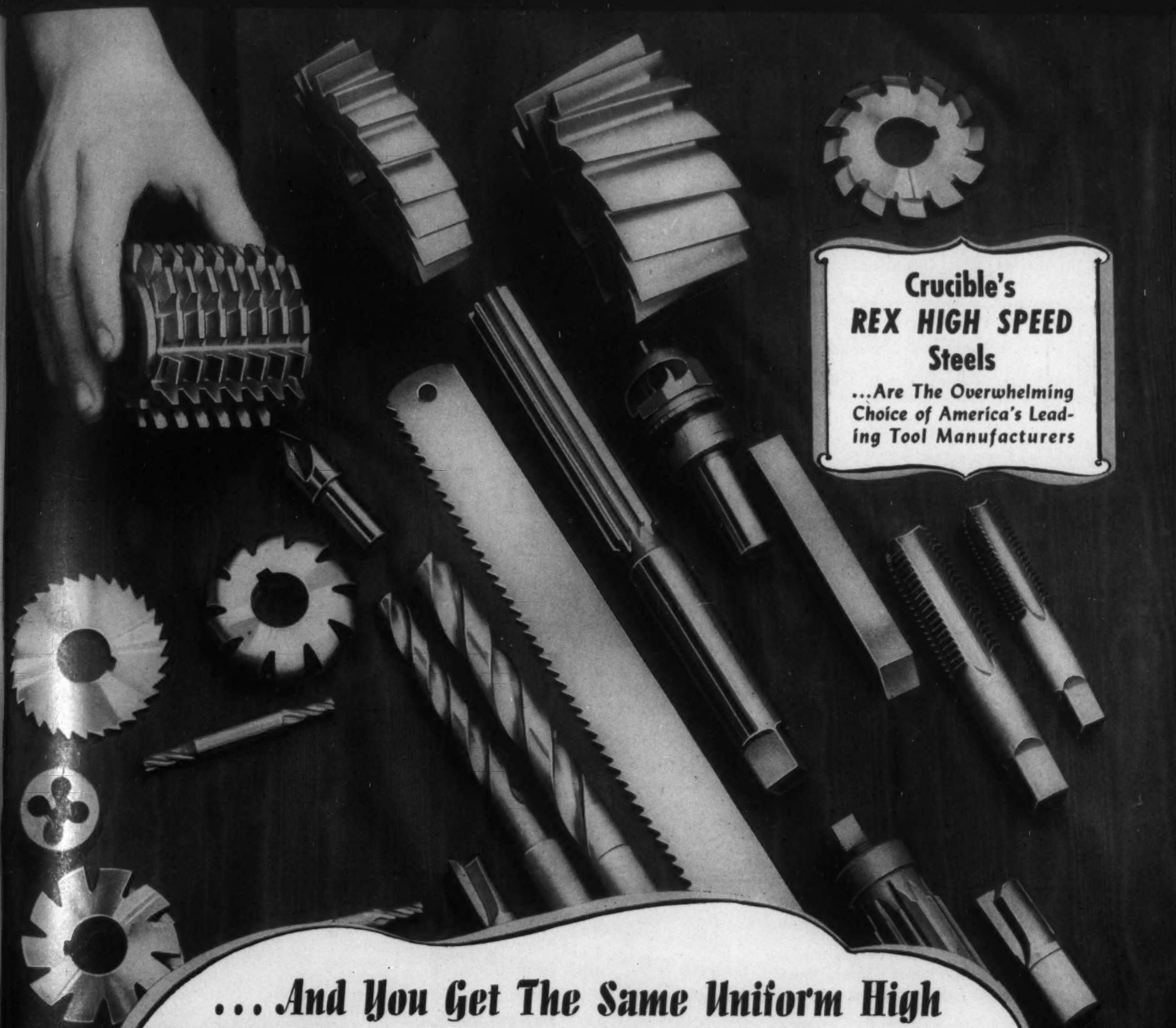
Slightly oxidizing flames and the application of flux continuously and prior to the welding operation are desirable. The forehand technique should be utilized, and flame and rod so manipulated as to produce a distinct ripple effect on the completed weld surface. For best "tinning," the inner cone of the flame should be about ¼ in. away from the surface of the puddle.

Cast Iron Filler Metal

In welding with cast iron rods it is just as important that the casting be properly prepared, adequately preheated and slowly cooled after welding. The rod should be as near as possible to the analysis of the parent metal, except that it should contain an excess of silicon.

A new technique of "low-temperature" welding with iron rods has been developed, in which the parent metal is not melted by the blowpipe but simply heated bright red. The molten iron from the rod is flowed over the surface, and fuses perfectly with a thin film of parent metal. The rod is melted by bringing it within the flame and letting droplets fall one by one onto one side of the vee, over which they spread.

A study of coated cast iron electrodes for d.c. arc welding of cast iron is reported by G. S. SCHALLER of Univ. of Washington ("Cast Iron Electrodes for Welding Gray Cast Iron," *Paper, Am. Welding Soc.*, Oct. 1940 meeting). Cast iron electrodes were coated by dipping with various mate-



Crucible's
REX HIGH SPEED
Steels
...Are The Overwhelming Choice of America's Leading Tool Manufacturers

... And You Get The Same Uniform High Quality When You Buy Rex High Speed Steels!

TODAY'S accent is still . . . and will continue to be . . . on QUALITY—DEPENDABILITY—UNIFORMITY . . . all the more necessary in light of today's accelerated production tempo. Leading manufacturers who are making huge quantities of tools like the above continue to rely on REX HIGH SPEED STEELS to meet their most exacting specifications. They depend on REX grades to maintain the high reputation of their products, and speed up their customers' production.

Whether or not you are similarly equipped to make exhaustive tests on incoming steel, you can safely rely on REX HIGH SPEED STEELS, because *all* REX brands are produced and inspected in our mills before shipment to conform to these exacting tool makers' standards. This is your assurance of dependability. And, the next lot you buy will be just as good, for the uniformity of REX HIGH SPEED STEELS is a tradition.

There are several types of REX HIGH SPEED STEELS . . . each outstanding for definite performance . . . and stocked in your local Crucible Warehouse or authorized distributor. Your Crucible "practical-man" will gladly survey your machining operations and give you specific recommendations. His vast background on the "Full-Range" of Specialty Steels is at your disposal. *Folder TS300 free on request.*

CHECK REX'S UNIFORM PERFORMANCE ON TOOLS LIKE THESE:

Broaches	Lathe Tools	Shaper Tools
Crowning Tools	Milling Cutters	Taps
Cutters	Planer Tools	Threading Dies
Drills	Punches	Tool Bits
Form Tools	Reamers	Wood Working Tools

CRUCIBLE STEEL COMPANY of America

Specialty Steelsmiths to INDUSTRY

CHRYSLER BUILDING • 405 LEXINGTON AVENUE • NEW YORK CITY
BRANCHES, WAREHOUSES AND DISTRIBUTORS IN PRINCIPAL CITIES

MAKERS OF HIGH SPEED, TOOL, STAINLESS, ALLOY, PRODUCTION AND SPECIAL PURPOSE STEELS

rials to overcome the hard spots and cracks encountered with bare electrodes. Preheated cast iron plates ½ in. thick were used as the parent metal.

Electrode performance depended on the coating in each case. Coatings that evolved considerable gas produced porous welds. Several of the coatings gave entirely satisfactory results, *e.g.*, a coating containing 15% graphite, 15% sodium carbonate, 6% titanium and 64% sodium silicate, and another with 13.1% graphite, 0.4% titanium oxide, 6.6% cellulose, 2.7% calcium carbonate, 4% ferrosilicon and 73.2% sodium silicate.

When welding was performed at 200 amps., gas and slag inclusions were less troublesome than at 125 amps. If there were excessive carbonaceous matter in the coating, a film of carbon formed on the vee at low currents and prevented smooth flow of metal and good root fusion and penetration. The average Rockwell hardness was 89 B for base metal, 95 B for fusion zone, and 100 B for weld metal.

Satisfactory arc welds can thus be made in gray cast iron with cast iron electrodes, if the core rod contain suitable alloying elements, and if the coating be suitably compounded.

Steel Electrodes

Mild steel and alloy steel electrodes, often in conjunction with silicon bronze filler metal, are also advantageously employed in welding cast iron. M. M. McElderry ("Arc Welding Heavy Sections of Cast Iron," *Ind & Welding*, Vol. 13, Aug. 1940, pp. 21-23, 39) gives some practical pointers in their use. A straight polarity alloy steel electrode is considered best because penetration into the cast iron will usually be less than with a reverse polarity electrode; the less the penetration, the less the carbon pickup in the weld metal, and the lower the weld hardness.

In arc welding heavy sections of cast iron, the crack should be veed out its full depth and the vee faced with the alloy steel. The bare silicon bronze rod (reverse polarity) is used to fill out the vee, and each bead is peened to relieve shrinkage stresses and improve the strength of the bronze. Studs should be used wherever possible.

The use of silicon bronze rod is limited to vertical and flat positions, and for overhead welding a shielded arc mild steel rod can replace the bronze rod. Welding will be much slower and a great deal of peening will be necessary.

Most weld failures in cast iron are believed due to shrinkage stresses set up during cooling. The alloy steel facing provides a good weld bond, and the silicon bronze weld-filling is soft enough to permit complete stress relief by peening. Beyond this, if all the usual welding precautions and the dictates of common sense be followed, heavy sections of cast iron can be successfully arc welded. X (2a)

2b. Non- Ferrous

Bright Copper Plating

"Electrodeposition of Bright Copper." Lawrence Greenspan. *Trans. Electrochem. Soc.*, Vol. 78, 1940; Preprint No. 13; 4 pp. Research.

The "bright" copper deposits obtained from the cyanide baths are not mirror bright and hence are not comparable in brightness to "bright" nickel deposits. Baths containing aliphatic amines were found to yield bright copper deposits.

A typical bath has the following chemicals in a liter of solution: $CuSO_4.5H_2O$, 100 g.; diethylene triamine, 80 cc.; $(NH_4)_2SO_4$, 20 g. The operating temperature is 140° F. and the current density is 40 amps./ft.^{2} As the bath has a pH of 9.0-9.5, ammonia is gradually lost, and concentrated aqua ammonia (3-5 cc./1.) must be added each day. Other amines of the ethylene series may be used in place of the diethylene triamine. The ammonium salt is important, as it eliminates the brittleness of the deposits and increases their brightness.

Steel must be flashed with copper in a cyanide bath before being plated in the above bath. Articles coated with bright copper can be plated with bright nickel without any intermediate buffing operation. AB (2b)

Metal Coloring

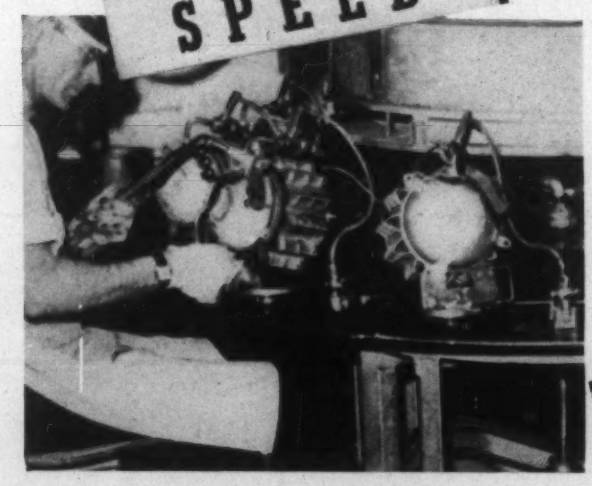
"Metal Coloring Theory and Practice." Joseph B. Kushner. *Products Finishing*, Vol. 4, July 1940, pp. 14-22; Aug. 1940, pp. 26-32. Descriptive series; for previous installments, see Metals and Alloys, Vol. 12, Aug. 1940, pp. 191-192.

Although neither cadmium nor zinc is often plated for purely decorative purposes, cadmium can be made to simulate old iron, pewter and oxidized silver. About the only compounds of cadmium and zinc suitable for coloring are a series of brownish oxides and a yellow-orange sulphide for cadmium, and a pale yellow chromate for zinc. Other colors must be obtained by depositing a second metal or metallic compound.

Among the finishes that can be produced on cadmium are artificial oxidized silver, various shades of yellow to brown, a black that resembles pewter, and an antique fin-

THERE'S NO TIME TODAY FOR EXPERIMENTS . . .

SPEED



On production set-ups like this, low temperature brazing makes brazing time per joint a question of seconds.

Fast Production with Reliability in finished products is the vital need of the hour. The sure way of meeting both demands is to use methods and materials that stand tried and proved!

When it comes to joining ferrous, non-ferrous and dissimilar metals, a time-tested way to get speed with reliability is to

. . . BRAZE WITH SIL-FOS and EASY-FLO THE LOW TEMPERATURE SILVER BRAZING ALLOYS . . .

RELIABILITY

The maker of this evaporator made over 100,000 joints (¾" diameter) with SIL-FOS without a single leak under air test.

Experience in plant after plant in many industries proved beyond question that SIL-FOS and EASY-FLO make joints of superior strength, soundness and reliability—and at the same time substantially reduce brazing time and costs.

PROVE IT IN YOUR OWN PLANT ON YOUR OWN WORK

That's the sure way to find out just what SIL-FOS and EASY-FLO can do for you. We'll gladly cooperate and send recommendations, if you'll tell us your problems, or have a field engineer call and demonstrate how to use these alloys. Write today. If you want literature ask for Bulletins MA-5, 9 and 10.

HANDY & HARMAN · 82 FULTON ST., NEW YORK

Agents in Principal Cities. In Canada: HANDY & HARMAN of Canada, Ltd., Toronto

ish. In the case of the black on cadmium, the reaction is a combination of displacement and oxidation whereby copper is displaced from its salts and then oxidized by chlorate present in solution. The piece must be agitated during the reaction to provide a satisfactory deposit of copper. With all these finishes the work will color best if taken directly from the cadmium plating bath, rinsed and put right into the coloring bath. Intermediate mechanical surface treatments produce changes that slow up the color deposition.

Blue and black can be produced on zinc. Black can be obtained by any one of several methods, and six of these are described. Other colors can be produced by depositing copper and then coloring it according to methods described in previous articles.

There are only 2 commercial ways to color aluminum: Precipitate other metals and their compounds, or make use of the absorptive properties of aluminum oxide. If preceded by a proper cleaning and pickling treatment, zinc and then copper can be plated on aluminum. The final deposit can then be colored in the usual way. Other colors that can be produced by deposition are iron gray, antique silver, dull gray, blues, black, yellow and bronze.

It is also possible to produce various oxide interference colors by treatment in a disodium phosphate bath. The patented aluminum oxide protective finishes can be colored by absorption of acid-type organic dyes. Basic type dyes can be used if preceded by a mordant. Sealing treatments help to make the colors fast. Inorganic pigments such as a yellow lead chromate have also been utilized. The color is obtained by a treatment of the oxidized aluminum first with sodium chromate and then with lead acetate. PCR (2b)

Welding Zinc and Its Alloys

"Welding Zinc, Tin, Bismuth, Antimony, Cadmium and Tellurium. A Review of the Literature to June 1, 1939." W. Spraragen & G. E. Claussen (Welding Res. Comm.) *Welding J., N. Y.*, Vol. 19, June 1940, pp. 209-s-217-s. Correlated abstract.

Zinc and its alloys are characterized by low melting point and high vapor pressure. Over-heating and the vaporization of zinc are the chief welding difficulties. The oxide film (ZnO) normally present on zinc is adherent, and flux is used to dissolve it.

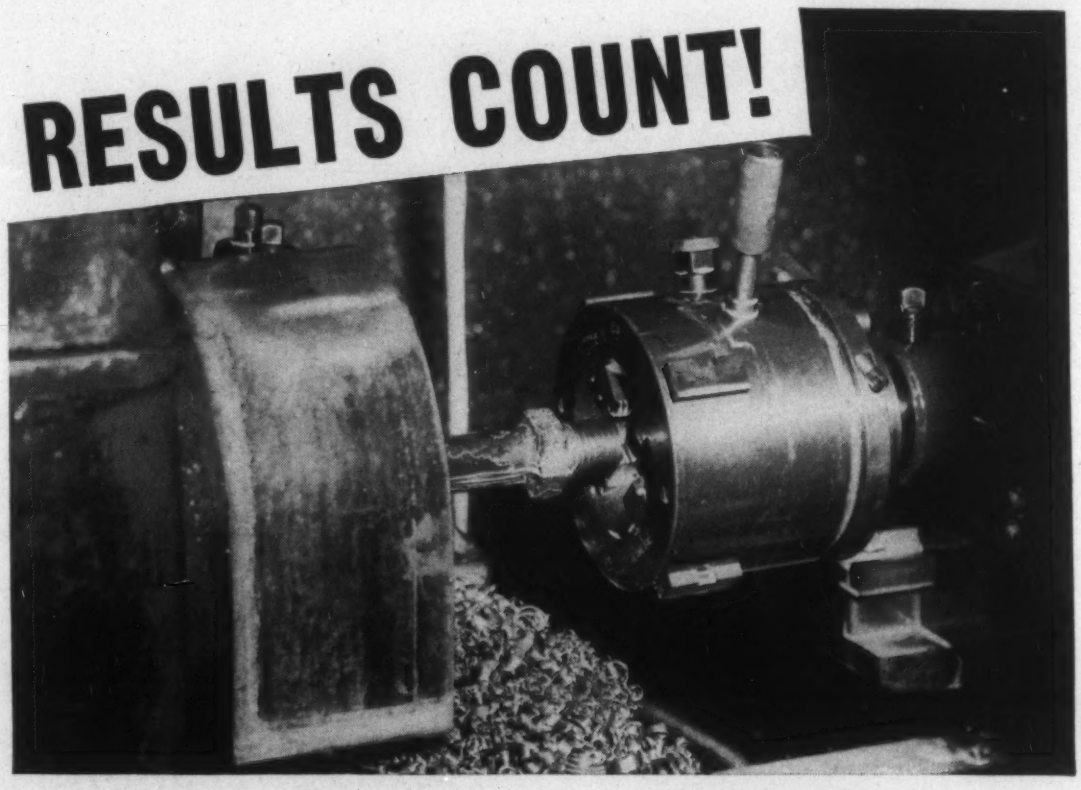
The flux should have good spreading power to prevent vaporization of zinc, should not fume, should not spot the surface of the weld and should be readily removable after welding. A powdered or paste mixture of 50% zinc chloride and 50% hydrated ammonium chloride has been used, the hot rod being dipped into it. Flux is used on both sides of the sheet and on the rod. A small torch is required, and the flame is small to avoid distortion and vaporization, and is neutral (not oxidizing). Pure zinc filler rod, or rod of the same composition as the base metal, are used, in sizes from 0.06 to 0.12 in. diam. The torch may be given an oscillating motion, and left-hand welding is preferred.

Clean welds free from porosity (X-ray) are prepared by experienced welders. The weld metal consists of large, columnar crystals. Hammering the weld (not too heavily) at 200°-300° F. refines the grain and improves the strength and ductility. Welds should have at least 90% of the tensile strength of unwelded metal and the same ductility, and equivalent corrosion resistance.

The air-acetylene flame is suitable for thicknesses up to 0.079 in. Portability is one of the chief advantages of the air-acetylene torch; about the same strength is attainable as with oxyacetylene welding. Zinc and zinc alloys free from aluminum can be hammer-welded at 660° F. with a ball peen hammer, but overheating must be avoided.

Spot welding has yielded satisfactory results, according to a number of investigators. Zinc containing 4% Al is best spot welded. Zinc spot-welds readily to aluminum, but poor, brittle welds are secured with ferrous and copper alloys, nickel, lead, cadmium and galvanized iron. Zinc is readily seam-welded, although coarse grain structure may be observed. Zinc can be resistance-butt-welded to itself and to tin.

Broken zinc-base die castings as thin as 1/32 in. have been oxyacetylene welded successfully by a number of experts, provided the castings have not been oxidized. The edges to be welded may be filed or scraped to a V with a steel spatula after being heated to the sweating point. The filler rod may be pure zinc or, better, a die casting alloy of the same type as that to be welded. Flux is sometimes used but most welders use none because alumina (from aluminum in the alloy) cannot be fluxed at welding temperatures. The majority prefer a reducing flame but no soot should be deposited. The flame should be directed on the filler rod to prevent overheating the casting. Plaster of Paris is used sometimes to support the casting during welding, while a graphite mold may be used to prevent liquid weld metal flowing away while the weld is being stirred. CEJ (2b)



"Excellent results for over five years have proved the value of Cities Service Cutting Oils in all of our operations, including threading, tapping and drilling," writes the purchasing director of a large electrical manufacturing company.*

This is but one of many examples where Cities Service Metal Cutting Lubricants have justified the title, "Service Proved." We will welcome an opportunity to tell you more about them and about our Lubrication Engineers' Service. Just fill out the coupon below and mail it for further information.

Copies of our booklet, "Metal Cutting Lubrication" are still available to users of metal cutting lubricants. Write for your copy today before the supply is exhausted.

*Name furnished on request.

CITIES SERVICE Cutting Oils "SERVICE PROVED"

FREE! JUST CLIP AND MAIL

CITIES SERVICE OIL COMPANY,
Sixty Wall Tower, Room 1626A, New York.

Please send me information concerning your Lubrication Engineers' Service ☐

Please send me booklet on Metal Cutting Lubrication ☐

Name.....Title.....

Business Address.....

Firm Name.....

City.....State.....

Machining Copper Alloys

"Machining Copper Alloys." W. B. Sallitt. *Can. Metals & Met. Inds.*, Vol. 3, July 1940. pp. 183-186. Descriptive.

Copper alloys can be placed in 3 groups: (a) Homogeneous materials, (b) duplex alloys, and (c) leaded alloys. Group (a) includes copper, alpha brasses, alpha aluminum bronzes, cupro-nickels, alpha "nickel silvers," wrought phosphor- and silicon-bronzes and beryllium-coppers in the softened or homogeneous condition. Group (a) materials in the cast form machine somewhat "shorter" than the corresponding wrought materials.

Group (b) includes the alpha-beta brasses, manganese-bronzes or -brasses, duplex aluminum-bronzes, alpha-beta nickel-brasses, cast phosphor- or silicon-bronzes and gun-metals. Metals of this group withstand much less plastic deformation when cold than do those of group (a). For alloys of low ductility, such as the hardest aluminum-bronzes or phosphor-bronzes, flat-topped tools produce the best results, but for gun-metal, brass, the manganese-bronzes and the majority of aluminum-bronzes a top rake of 8°-12° is advocated.

Group (c) consists of copper alloys either of homogeneous or duplex basic structure to which additions of some agent have been made to improve machinability. Selenium and tellurium exercise an effect similar to that of lead, so copper alloys containing such elements should be placed in this group. Additions of lead improve the machinability of copper alloys by decreasing the resistance to cutting and by breaking up the chips. Lead also serves as a lubricant between the tool and work, improving tool life. Leaded alloys are machined with tools ground with a top rake angle of less than 8°.

Most copper alloys can be machined at extremely high speeds, particularly with carbide tools. Group (c) materials are eminently suited to intricate work on automatic machines, since they produce short flaky chips that are readily flushed away. Group (b) materials may sometimes require chip breakers; group (a) alloys are seldom susceptible to chip breaking, and turnings can be coiled closely only if light cuts are taken. Generally speaking lathes used for ordinary brass-finisher's work are not suitable for high-tensile brasses and bronzes.

For cutting tools, carbon steels resist abrasion very well and are used for certain finishing operations and for taps and dies for threading copper. High speed steels are preferable for high-production work. Tungsten carbide- or Stellite-tipped tools can be used without cutting fluids at extremely high speeds on all copper alloys. On center lathe work, where tools may readily be reground, high speed steel tools may prove most economical, but in capstan lathe or automatic work the use of tipped tools may permit higher cutting speeds, with substantial production increases.

Tools operating on lead-free materials of groups (a) and (b) usually fail through wear caused by chips sliding over the tool face. With leaded or similar materials chip friction is almost negligible; tool life is practically independent of cutting speed and (in roughing operations at least) group (c) materials should be cut at the maximum speed and feed provided by the machine.

WHB (2b)

adds strength to one of your strongest selling points!

You can sell the *durability* of your products when you *build it in* them . . . with Kester Cored Solders.

Difficulties with solder and solder fluxes have been a bugbear for many manufacturers until Kester supplied the right solders and the right fluxes for permanent, quality construction.

Many metals and alloys are used today. No one type of solder will do perfect work on all of them. For this reason Kester engineers have developed specific industrial solders for each type of metal work.

On the metallurgical side, the solder-alloy and solder-flux must be exactly adapted to the metals involved. On the mechanical side, the solder strand-size and core-size must be right for speedy handling and precision workmanship.

Kester engineers will give you expert advice on the right solder for each of your operations. This advice is backed by forty-three years of industrial solder experience.

You are cordially invited to call on Kester engineers to help you speed up production and add strength to your product.

KESTER SOLDER COMPANY

4219 Wrightwood Avenue — Chicago, Illinois

Eastern Plant: Newark, N. J.

Canadian Plant: Brantford, Ont.

KESTER CORED SOLDERS

STANDARD FOR INDUSTRY

Producing Aircraft Parts of Magnesium Alloys

"Production of Magnesium-Alloy Aircraft Parts." L. B. Grant (Dow Chemical Co.) *S.A.E. Journal*, Vol. 47, Aug. 1940, Trans. pp. 325-331. Practical.

The most commonly-used magnesium alloy for sand castings and permanent mold castings is one containing 6% Al, 3% Zn and 0.2% Mn (Dowmetal "H"). For low-stressed parts like oil-tank fittings, which require excellent weldability, castings are made of Dowmetal "M" or similar alloys, containing 1.5% Mn, remainder magnesium. Design of magnesium alloy castings is of great importance because of their considerable notch sensitivity.

Magnesium alloys of the Dowmetal "H" type may be used as-cast if service stresses are low, solution-heat-treatment if shock resistance is most important, and age-hardened if high hardness or yield point is vital. Because of their lower modulus of elasticity than aluminum alloys, magnesium alloy castings should have a 15% greater wall thickness than aluminum alloys if equal wall-stiffness is desired.

In machining magnesium alloys, machine-tools of standard design may be used in most cases. To avoid fire hazard, it is of utmost importance that cutting-tools be very sharp and ground with adequate relief to secure a true cutting action with as little friction as possible. Ordinary machining operations may be done dry, but on high-speed operations, kerosene or other oil-type coolants should be used. Aqueous solutions or emulsions are not recommended. If fire occurs, it should be extinguished with dry materials such as cast-iron borings, pow-

In the Pickling Solution

RODINE

Keeps the acid from eating good metal. Thus it stops waste of both acid and metal. It also prevents over-pickling, eliminates acid fumes, and reduces acid embrittlement.

One result of these advantages is lowered costs; other results are increased tonnage and brighter pickling.

Give us the particulars of your pickling process—the kind of metal, kind of acid used, acid concentration, temperature of bath. We can then suggest the grade of RODINE that will improve your pickling.

Bulletin on request

AMERICAN CHEMICAL PAINT CO.

Dept. 307, AMBLER, PENNA.

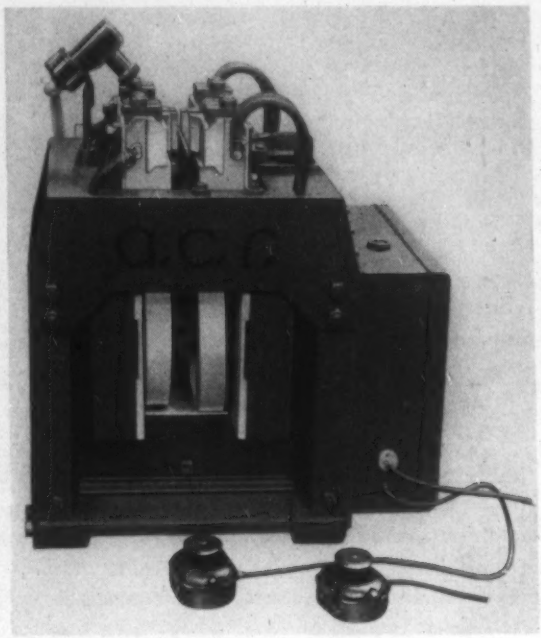
DETROIT, MICH. WALKERVILLE, ONT.

a.C.f. Air-Operated

BERWICK ELECTRIC HEATER

a.C.f.

BERWICK ELECTRIC NO. 3 TYPE "L" HEATER, equipped with Electric Eye for controlling temperature; heats any diameter from ⅛ to 1"; any length heat from 1" up; water-cooled electrodes. Gives an end heat or a heat at any point on the bar.



Electric heating due to its speed, does not develop scale during process of heating.

State your problem, giving sizes, length of heat and production desired, when we will give you our recommendations.

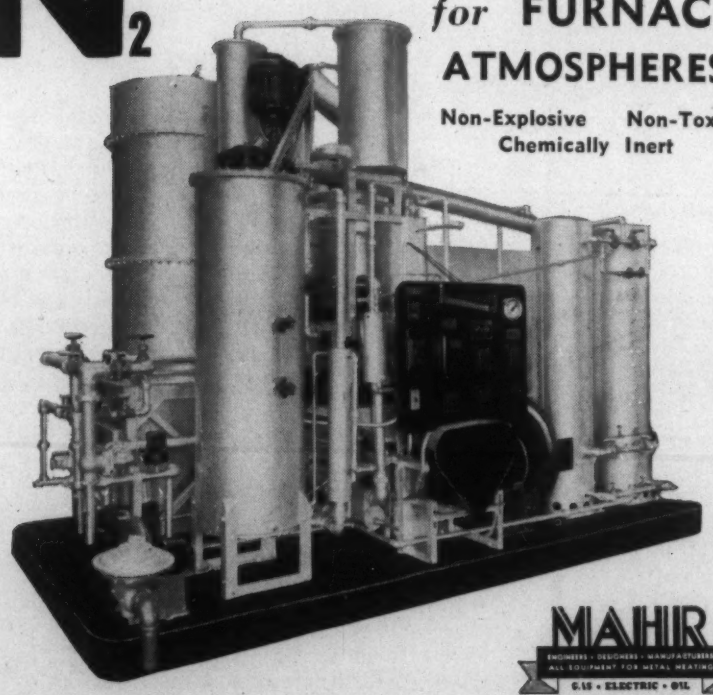
AMERICAN CAR AND FOUNDRY COMPANY

30 Church Street New York, N. Y.

CHICAGO DETROIT ST. LOUIS

N_2 AT VERY LOW COST *for* FURNACE ATMOSPHERES

Non-Explosive Non-Toxic
Chemically Inert



MAHR
ENGINEERS · DESIGNERS · MANUFACTURERS
ALL EQUIPMENT FOR METAL HEATING
GAS · ELECTRIC · OIL

Nitrogen

For clean hardening and bright annealing. Will not scale or decarburize ferrous metals. For bright annealing of non-ferrous metals. Aids carburization. Is a substitute in many applications for bottled carbon dioxide at lower cost. Reduces deterioration, prolonging service life of alloy tubes, muffles and retorts. Non-explosive, non-toxic and chemically inert. A purge for inflammable and explosive fumes in tanks, containers, etc.

Write for FACTS on YOUR Problems

FURNACES

Rotaries—Car Types
Conveyor—Roller Hearth Pusher Types
Tool—Pot—Crucible
Open Front Batch
Babbitt

●

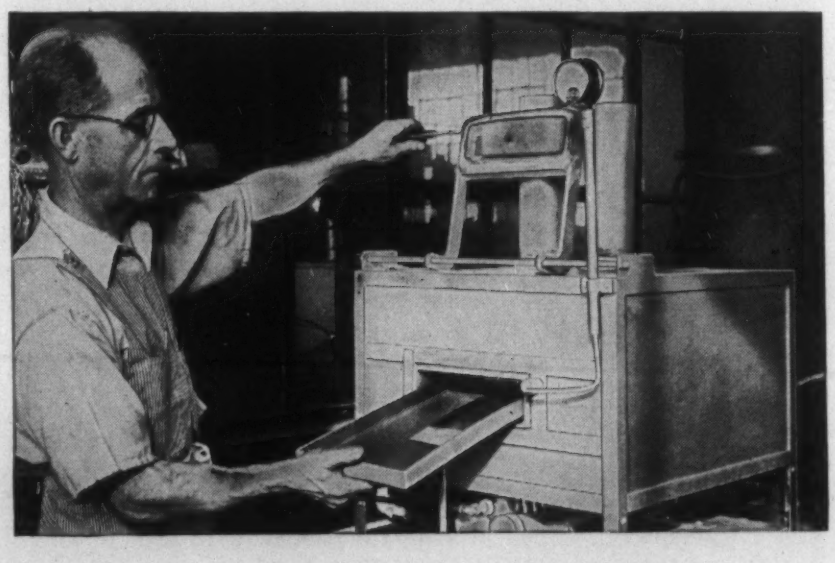
Rivet Heaters—Forges
Core Ovens

MAHR MANUFACTURING COMPANY

DIVISION OF DIAMOND IRON WORKS, INC.

MINNEAPOLIS · MINNESOTA · U · S · A

1850° to 2450 °F Without Blower or Compressed Air



Baker small gas fired furnaces prove that high temperatures can be obtained without blower or compressed air. Noiseless. Easy to install. Economical. There are Baker furnaces for tool rooms, for treatment of high speed steel and a hydrogen furnace for bright annealing, brazing and soldering without flux. Send for catalogue.

BAKER & CO., INC.

High Temperature Furnace Division

113 ASTOR ST. NEWARK, N. J.

dered asbestos or graphite, not with water or with liquid extinguishers.

Immediately after machining, the castings should be cleaned and then given a chemical surface treatment to improve the corrosion resistance and offer a good base for painting. Four new treatments are now available; these are Dow No. 6 (where painting is not possible) and anodic, Dow No. 7, and Dow No. 8 (all to be used under paint).

Dow No. 6 is harder than the casting and thus offers some abrasion resistance as well as corrosion resistance. It is applied in an autoclave at temperatures up to 400° F. and pressures up to 225 lbs./in.^{2} Dow No. 7 is somewhat better than No. 8 and is much more effective than the chrome-pickle treatment. It consists essentially of a 5-min. dip in weak hydrofluoric acid at room temperature followed by a 45-min. boiling in a water solution containing 10% by weight of sodium bichromate. The outstanding advantage of this treatment is that casting dimensions are not changed. The coating formed is dense and smooth.

The best all-purpose magnesium alloy for die castings is one containing 90.2% Mg, 9% Al, 0.6% Zn and 0.2% Mn (Dowmetal "R") although for applications permitting lower yield strength an alloy containing 93.1% Mg, 6.5% Al, 0.2% Mn and 0.2% Si (Dowmetal "Ex") may be used. Machining, cleaning and surface treatment are the same as for sand castings.

Magnesium alloys are suitable for hammer and press forgings. Hammer forgings are somewhat lower in cost and can be made closer to dimensions than press forgings, but the hammer-forging alloys do not develop as high strength as do the press-forging alloys. Machining and surface treatment of forgings are the same as for sand castings. Use of magnesium alloys in extruded form is expanding.

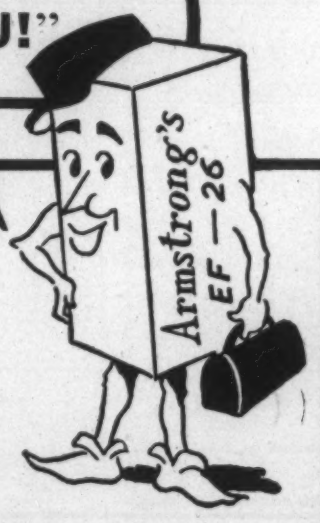
Dowmetal "M" is the most widely used alloy in sheet form, and should be retreated with chrome-pickle or anodic treatment after forming and before assembly. Annealed sheet can be bent cold around radii down to 4 *t* and hard-rolled sheet down to 8 *t*. If sharper bends than 4 *t* are required, the sheet must be hot-worked at 500°-750° F. The tools for this operation should be clean, smooth and well lubricated, with lard oil, for example. Sharp corners and burrs must be removed from the edges of the sheet near the bend line. Bending lines should not be prick-punched, as fatigue cracks may result.

Hot-forming can be done successfully with the regular drop-hammers used in the aircraft industry. However, magnesium or aluminum dies should be used instead of the usual lead or zinc dies. The female die should be heated to about 400° F., and the sheet should be preheated in an oven to about 700° F. In all heating operations, temperatures must be kept below 800° F. to avoid grain growth. Very little spring-back occurs on hot-worked sheet. The temperatures just given are also used in power drawing magnesium alloys. Drawing speed should be less than for other metals, and, therefore, hydraulic presses are best suited for this purpose.

Magnesium alloys can be welded successfully with the oxyacetylene torch, Dowmetal "M" being the easiest alloy to weld. The welding rod should be of the same composition as the material being welded, and the flame should never be allowed to become oxidizing. Special fluxes are required, and it is important that the flux be cleaned thoroughly from the weld immediately after welding.

Welds should be designed so that the flux is not trapped, and, therefore, lap welds should be especially avoided. In assembling magnesium alloy parts, they should be protected suitably or insulated where two surfaces come in contact, particularly if the alloy touches a dissimilar metal or wood. In addition to the surface treatment given previously, zinc chromate primer, sealing compounds, or gaskets should be used in the joint. After assembly, the parts should be painted wherever possible. Army and Navy specifications for paints and finishes for aircraft are satisfactory; for exposed surfaces, one coat of primer should be used followed by two or more finish coats. MS (2b)

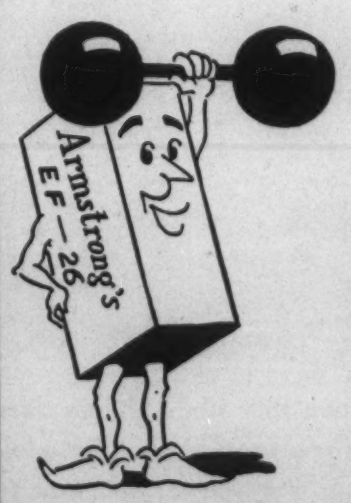
"I WORK BEST WHEN THE HEAT'S ON—LET ME WORK FOR YOU!"



WORKING under pressure and severe heat is duck soup for me—in fact it's my sole purpose in life. You see, I'm a heavy-duty insulating fire brick, and a mighty efficient one at that. I can be used in practically any service up to a hot face temperature of 2600° F. and I have a cold crushing strength of 450 lbs. per square inch. Armstrong's EF-26 is my name, and I'm sure proud of it!

To begin with, I'm made of fine material. I have to meet most rigid specifications and strict tolerances. Then Armstrong makes me pass breaking strength tests, thermal conductivity, spalling resistance, crushing strength, and other grueling tests before I'm allowed to look for a job in any furnace. For only after measuring up in all qualifications is a brick given the Armstrong name!

I've been through all that now and naturally am anxious to go to work. I can cut fuel costs, speed production, and insure more accurate temperature control. Tests have proved that I meet the essential requirements for efficient service—low thermal conductivity, high physical strength, uniformity in size and composition, low shrinkage and ample refractoriness for the use intended. How about a job in your furnace?



I'll be glad to give you more information about me and about the rest of Armstrong's complete high temperature line including cements if you'll write to Armstrong Cork Co., Building Materials Division, 982 Concord Street, Lancaster, Pennsylvania.

~ ~ ~

Color now aids the easy and accurate identification of the five types of Armstrong's Brick.

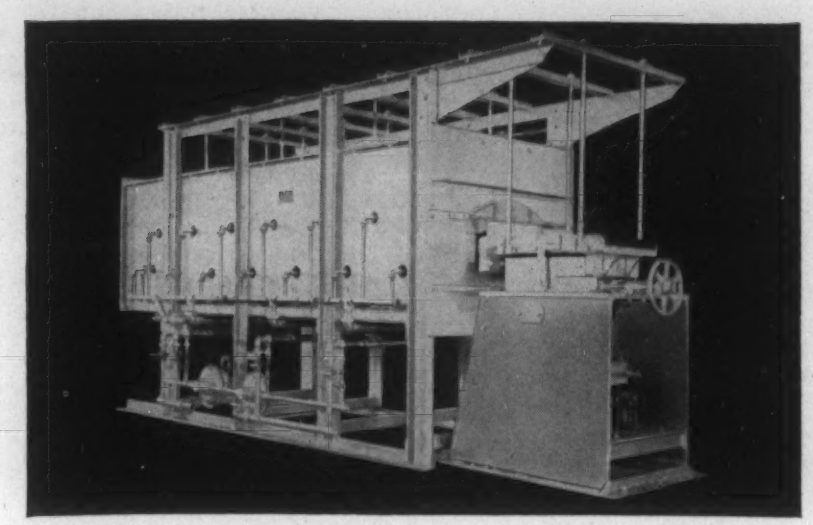
Armstrong's

HIGH TEMPERATURE INSULATION

Cadmium Plating —A Correction

In a composite digest on cadmium plating published in our September issue, p. 339, a formula for a bath for still plating was incorrectly given as 4 oz. cadmium oxide and *1* oz. sodium cyanide per gallon. The author of the *Iron Age* article from which these data were extracted, Adolph Bregman, informs us that the formula as originally published embodied 10 oz. sodium cyanide.

Although our modification might be considerably cheaper, we too doubt its ability to produce a tolerable plate. With our apologies to Mr. Bregman we offer the usual excuse that the error was typographical. —F.P.P.

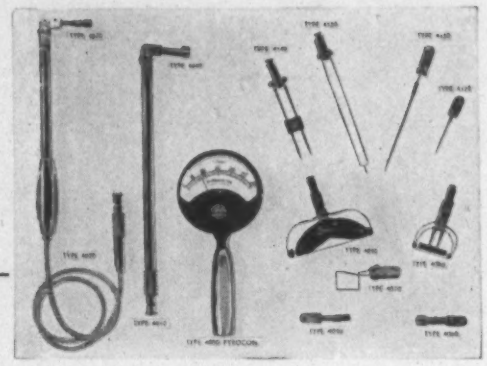


CLEAN HARDENING !

OF YOUR FORGINGS, WRENCHES, CHAIN LINKS, CARTRIDGE CLIPS AND SIMILAR WORK IN OUR FULL MUFFLE RECIPROCATING HEATING MACHINES.

Specific Information is yours for the asking

American Gas Furnace Co.
Elizabeth, New Jersey



The Improved "Alnor" Type 4000 Pyrocon

for surface temperatures

The Alnor Pyrocon which has had such wide acceptance for every type of application now offers many new and exclusive features.

1. Unusually heavy and rugged movement—highly essential in a portable pyrometer.
2. Choice of either rigid or flexible arms or both which are instantly removable and interchangeable.
3. Improved and enlarged assortment of thermo-couples all of which are instantly interchangeable without change in instrument calibration.
4. Choice of seven standard temperature ranges.
5. Greater accuracy. Yoke of arms and side plates of thermo-couple assembly made of thermo-couple material to eliminate junction errors.

Regardless of your application the Alnor Pyrocon will prove the most economical.

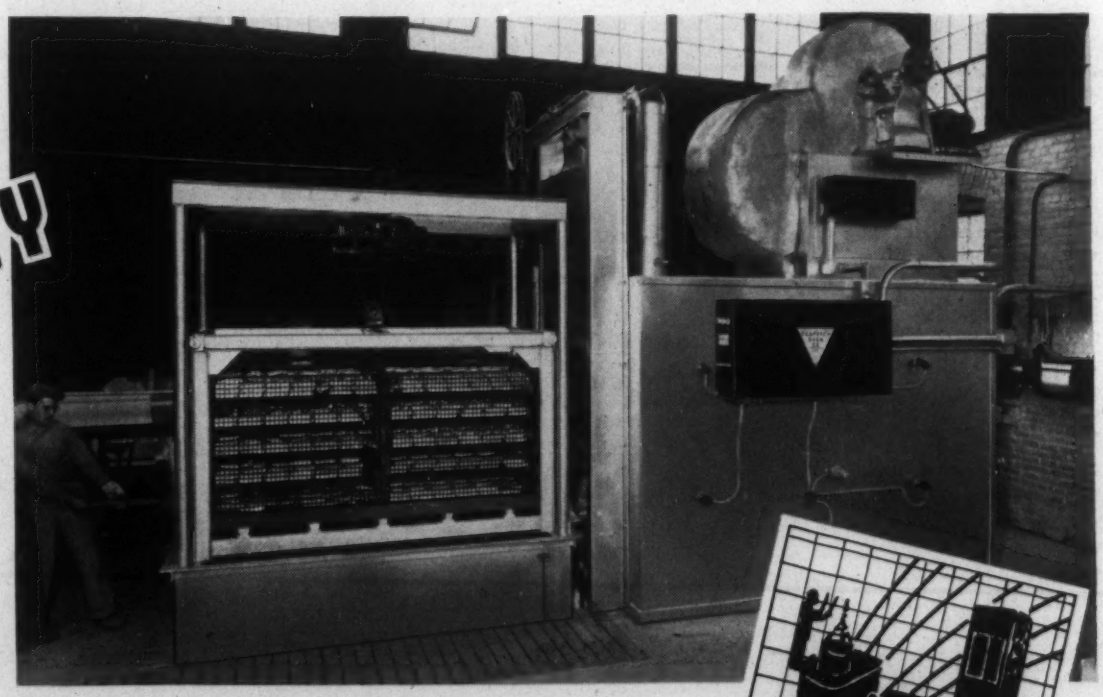
Write for folder #3511.

Illinois Testing Laboratories Inc.
425 N. LaSalle St., Chicago, Illinois

A HIGH STANDARD OF ACCURACY

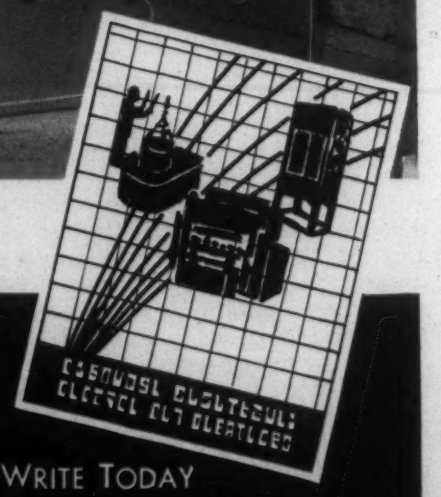
for
Magnesium Alloy
Aluminum Alloy
Castings

Despatch designed Furnaces for batch or conveyor type handling speed production and accurately heat treat ferrous and non-ferrous metals.



This Despatch Furnace was designed to accurately solution heat treat magnesium and aluminum alloy castings. The design speeds production and reduces handling. The rack slides from the furnace and is lowered by the hoist into quenching vat.

TODAY'S standards for aging and solution heat treating alloy castings are most rigid. The new uses for non-ferrous alloys widen the foundry's scope of operations. At the same time make new and serious demands for accurate heat treating. The Despatch Furnaces are designed for that accuracy, as well as economy. A straight line temperature control will be easy to maintain if you operate a Despatch Furnace.



WRITE TODAY
for full furnace facts as outlined in the new DESPATCH BULLETIN NUMBER 81

DESPATCH OVEN CO.

MINNEAPOLIS MINNESOTA

3 Properties and Applications

METALS, ALLOYS, METAL FORMS ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep). Corrosion and Wear. Engineering Design of Metal-incorporating Products. Selection of Metals and of Metal-Forms. Competition of Metals with Non-Metals. Specific Applications of Metals and Alloys.

Metals for Bursting Disks

"Designing for Failure." R. V. Sutherland (Black-Sivalls & Bryson) *Steel*, Vol. 107, Aug. 12, 1940, pp. 46-49. Descriptive.

Metals are the most satisfactory materials for bursting disks. In these, the metal must flow under "near-bursting stress" until it attains such a shape as permits the minimum stress for the load. Almost all metals obtainable in sheet form, including aluminum, copper, steel, stainless steel, Monel, gold and platinum, have been used.

Laminated combinations of base and more precious metals are most generally employed, with laminated aluminum-and-gold and aluminum-and-silver classed as newcomers. Aluminum and copper are most widely used.

The metal must be thick enough to flow into the new semi-spherical shape without excessive thinning. Disks have been made as thin as 0.002 in. The disks will ordinarily be stressed to ⅔ their ultimate strength under ordinary working pressures. With many materials, this means they are stressed beyond their elastic limit. The determining factor for maximum permissible stress is the "upper creep limit" or the value beyond which the material flows so rapidly as to fail in a comparatively short time. Metals like lead, tin and zinc are unsuitable for disks because their creep limit is so low compared with their ultimate strength.

Most published values for creep are very difficult to apply in manufacture of disks, and the designer must therefore resort to direct experiment to determine creep limits and other factors such as fatigue, temperature, corrosion, etc.

Where pressure vessels are subject to pulsations, fluctuations, or alternate pressure and vacuum, the fatigue limit is likely to be the determining factor in figuring the ratio of bursting pressure to working pressure. Working pressures must be held considerably below those for more static loads. For example, an aluminum disk will serve more satisfactorily under severe pulsation if the ratio of bursting pressure to working pressure be 2 rather than 3/2.

The choice of metals and range of bursting pressures narrow sharply for high temperature applications. Aluminum is worthless at above 300° F. Copper has been used successfully at somewhat higher temperatures. Stainless steel and Monel are most suitable for very high temperatures. Nickel has the apparently unique and valuable property of preserving an upper creep limit very close to its ultimate strength at comparatively high temperatures. MS (3)

Aircraft Sheet Materials —Fatigue and Damping Properties

"Fatigue and Damping Studies of Aircraft Sheet Materials: Duralumin-Alloy 24ST, Alclad 24ST and Several 18/8 Type Stainless Steels." R. M. Brick & Arthur Phillips. *Preprint, Am. Soc. Metals*, Oct. 1940, 28 pp. Research.

The strong wrought aluminum alloys, 24ST and Alclad 24ST, and nine 18/8 type commercial grades of stainless steels of low and moderate carbon contents, and in the annealed, cold-rolled, stabilized and aged conditions were fatigue-tested under constant-deflection conditions. The S-N data so obtained indicate the probable endurance limits but are incomplete because of lack of time for aluminum alloys and the scatter of results for many of the stainless steels.

The ratio of endurance limit to tensile strength of the stainless steels was found to be relatively constant for one type of surface condition but to change a maximum of 30-70% with different commercial finishes. The effects of the two opposing factors, work hardening and cracking, were studied by means of damping and mechanical hysteresis (load-bending) tests on actual fatigue specimens at various intervals during stressing above and near the endurance limit. Considerable changes took place in Alclad but changes in the stainless steels were relatively slight, although differences were found among the various types studied.

Taking into account all the possible errors, the probable endurance limits in lbs./in.^{2} of the aluminum alloys were reported as follows: 24ST (rolling direction parallel to specimen axis) 16,500; Alclad (rolled parallel to axis) 11,000; Alclad (rolled transversely) 10,000. The relatively low fatigue strength of Alclad 24ST seemed to be related to the formation of large numbers of shear cracks in the weak aluminum surface layer and their propagation into the alloy core.

Despite a considerable scatter of points on the S-N fatigue curves of the stainless steels, the data showed a general tendency for the endurance limit to remain in the range of 30-40% of the tensile strength for the commercial finish No. 2-B, a bright finish which, nevertheless, shows etched grain boundaries from the prior pickling operation. Severe cold rolling after pickling did not remove the grain boundary etch effect nor did it appreciably raise the endurance ratio. An extremely fine ground finish, No. 4, obliterated the etched boundaries and increased the endurance limit to the range 60-70% of the tensile strength.

Fatigue stressing of Alclad 24ST above the endurance limit sharply decreased the damping at high stresses and as failure became imminent, *i.e.*, fatigue cracks were propagated into the core, the damping at low stresses greatly increased. Fatigue stressing of Alclad in the vicinity of the endurance limit showed the same sharp decrease in damping at high stresses but not the later increase at low stresses. Among the stainless steels, the damping capacity decreased almost continuously with increase in tensile strength. FPP (3)

3a. Ferrous

Copper- and Nickel-Alloy Steels —Atmospheric Corrosion Resistance

"Atmospheric Durability of Steel Containing Nickel and Copper." N. B. Pilling & W. A. Wesley (Intn'l. Nickel Co.) *Preprint, Am. Soc. Testing Mat'ls.*, June 1940, 15 pp. Research

The results of six series of atmospheric corrosion tests and data from a service test in coal cars are presented to evaluate the durability of sheet specimens of low-alloy steels containing nickel and copper.

Various combinations of nickel (up to 7%) and copper (up to 7%) were exposed at 4 sites—rural, marine, mild industrial and severe industrial in 1925. This test is still continuing (with the unfortunate exception of the marine rack, which was carried out to sea by a storm). At this location, ingot iron had a life (to first perforation, 0.02 in.) of 1.5 yrs.; 0.17% Cu steel—1.5 yrs.; 3.0 Ni, 6.1 Cu—3.5 yrs.; 4.2 Ni, 1.8 Cu—5 yrs.; and 1.39 Ni, 0.61 Cu; 2.76 Ni, 1.18 Cu; 2.8 Ni, 1.2 Cu; 5.42 Ni, 2.36 Cu; 6.95 Ni, 3.03 Cu—all over 5 yrs. Other locations showed similar results.

A simulated roofing sheet test, designed to cover in one test sheet all conditions to which roofing sheets are exposed, was started in 1933 and is still continuing. The gutter section of all sheets had failed at the end of 6 yrs. except those in the rural atmosphere. In the gutter section, copper steel was superior to the non-copper Bessemer steel; phosphorus added to copper was beneficial and an excess of nickel over copper was necessary to produce a nickel-copper sheet that showed considerable superiority to the copper steel. On the remaining sections, copper steel was superior to non-copper Bessemer, and the nickel-copper steels were superior to the copper steel; only 2 of the nickel-copper combinations have failed as yet at all locations.

Six yrs. service in railroad coal cars gave for the nickel-copper steels, on the average, 50% of the deterioration shown by copper steel, which in turn was more resistant than the carbon steel.

N-A-X

High Tensile

This superior low alloy, high tensile, high ductile steel is regularly being used in the manufacture of many types of equipment for the defense program.

You need not take chances on having your designs rejected because the high tensile, low alloy steel doesn't meet specification for armament parts. Many long months before the armament program got under way Great Lakes engineers made sure that N-A-X HIGH TENSILE had all the physical properties necessary for this type of work. N-A-X HIGH TENSILE is regularly being used by manufacturers making a variety of parts for the defense program because N-A-X HIGH TENSILE has—

DUCTILITY—assuring long fatigue life and ease of fabrication.

STRENGTH

Typical Properties of 7/16-inch Thick Plate

Condition of Plate	Yield Point	Tensile Strength	% Elongation	R.A.
As Rolled	56,690 p.s.i.	83,000 p.s.i.	40%	
Stressed Relieved (six hours at 1115°F. Furnace cooled.)	55,410 p.s.i.	81,650 p.s.i.	44%	
Heat Treated	126,200 p.s.i.	135,150 p.s.i.	22.6%	54%

IMPACT RESISTANCE

+75°F	65 foot pounds (Charpy Keyhole)
−25°F	50 foot pounds (Charpy Keyhole)

EXCELLENT WELDABILITY—A steel with the combined properties of N-A-X HIGH TENSILE as given above and possessing the excellent weldability as this low alloy high tensile does, enables the fabricator to produce products that meet the very exacting specifications for defense equipment.

N-A-X HIGH TENSILE also enables the fabricator to turn out parts and products economically because this unusual low alloy steel goes through each phase of manufacture smoothly, easily, quickly.

Call on Great Lakes engineers to show you how you can use this really superior high tensile steel to advantage. One will be glad to call at your convenience—no obligation. Wire, write or telephone for one today. Great Lakes Steel Corporation, Detroit, Michigan.

GREAT LAKES STEEL CORPORATION——DETROIT, MICHIGAN

Boston, 460 Statler Office Building; *Buffalo,* 1000 Walbridge Building; *Chattanooga,* 18 Volunteer Building; *Chicago,* 1026 Builders Building; *Cleveland,* 820 Leader Building; *Dayton,* 1401 Third National Bank Building; *Indianapolis,* 1215-17 Circle Tower; *Minneapolis,* 714 Midland Bank Building; *New York,* 405 Lexington Avenue; *Philadelphia,* 407 Liberty Trust Building; *St. Louis,* 3615 Olive Street; *San Francisco,* 824 Sharon Building; *Toledo,* 906 Edison Building. *Montreal, Quebec,* Drummond, McCall & Co., Limited; *Toronto, Ontario,* Peckover's, Limited.

division of NATIONAL STEEL CORPORATION

Executive Offices, Pittsburgh, Pa.

Non-Ferrous Alloys

of

TANTALUM COLUMBIUM
TUNGSTEN MOLYBDENUM

And Their Carbides

High purity alloys and master alloys of tantalum, tungsten, columbium and molybdenum with nickel, cobalt, chromium and other base metals, scientifically produced by powder metallurgy or electric furnace fusion.

Fansteel has complete equipment and trained personnel for all powder metallurgy processes, centrifugal and still casting, rolling, swaging, wire drawing.

Write your problem in complete detail. All consultations confidential.

FANSTEEL

METALLURGICAL CORPORATION
NORTH CHICAGO ILLINOIS

THE WORLD'S PREMIER POWDER METALLURGISTS

WHEN YOU NEED

dogged, die-hard RESISTANCE

TO CORROSION
HEAT AND ABRASION

You'll find these properties in INDIUM—the Practical COMMERCIAL METAL FOR ALLOYING AND PLATING.

INDIUM—as a Plating Medium—is deposited electrolytically on a required surface . . . Subsequent heat treating DIFFUSES IT into the metal, making it a part of the actual surface itself—thus, INDIUM can never chip or peal!

INDIUM—as an Alloying Element—is daily proving its stamina in the bearings of the new line of WHITE Super Power TRUCKS. . . Here INDIUM demonstrates its remarkable ability to stand up under the corrosive action of mineral acids in the oil, heavy-load drag and high-speed heat.

• ***We urge you to write for the facts about INDIUM today!***

Specify INDIUM

THE • INDIUM • CORPORATION • OF • AMERICA
INCA

Sales Office and Laboratory 805 Watson Place, Utica, N. Y.
Research and Development Office 60 East 42nd Street, N. Y. C.

THE INDIUM CORPORATION OF AMERICA

The National Bureau of Standards' 5.5-yr. test on corrosion resistant materials showed less corrosion for the 2% Ni, 1 Cu combination than did a plain carbon, a 0.52% Cu, 0.15 Mo steel, and a 5% Cr steel. An extensive series of some 200 experimental nickel-copper steels of 0.015 in. gage were exposed in 1933 as simple rectangular panels in the Bayonne, N. J., industrial atmosphere. Results to date indicate that manganese, silicon and carbon contents are with influence. Phosphorus is beneficial when added to nickel and copper steels and the 2-1 and 3-1 Ni-Cu combinations far superior to the other steels.

The corrosion-time relationship was measured using the electrical resistance method. The superiority demonstrated by the alloyed steels becomes progressively greater with increase in duration of the exposure, hence with increase in gage of the metal being tested. The more rapid decrease in rate of corrosion with time with the alloyed steels is related to the structure and protective value of the rust coatings. Steels with rapid rates of corrosion developed very coarse-textured rust coatings while the more resistant steels were readily recognized by the fineness and good adherence of their rust.

A group of 11 structural steels was exposed to the Bayonne atmosphere in 1934. One set was exposed to the atmosphere and the other outdoors half-immersed in water. Each steel was exposed in triplicate to provide for the removal of a complete set at the end of 1, 3 and 8 yrs. The first 2 periods of test have been completed for the atmospheric set and the semi-immersion test was completed in 20 months. The more highly-alloyed steels were definitely superior to the others in both the atmospheric and partial-immersion tests. In the atmospheric test, the marked drop in corrosion rate with time in the first 3 yrs. indicates that tests of this sort should be continued for many years if the true relative longevity of alloy steels is to be established. VVK (3a)

Forgings vs. Castings

A Composite

A book could be written about the factors to be considered in choosing between forgings and castings in designing various industrial products, so we can't pretend that this brief "composite" sums up the matter for all time. But the many real advantages of forgings have been too infrequently stressed in comparison with all the publicity given castings, die castings, and weldments, and what follows is intended to be something of a corrective.

The extent of application of forgings is greater than is usually realized, and too often they are simply taken for granted because of their trouble-free service, says M. B. PENDLETON of Plomb Tool Co. ("Forgings and Forged Tools in Industry," *Heat Treating & Forging*, Vol. 26, Sept. 1940, pp. 446, 463). Forgings provide strength through flow lines and homogeneous structure rather than by metal bulk; lighter weight parts are therefore permissible. Forgings are shaped in closed dies and require a minimum of machining. Uniformity of properties can be easily achieved through heat treatment.

In the forging process strength is achieved through improvement of grain structure at the points of greatest service-shock or strain. Freedom from concealed defects is said to be an outstanding characteristic of forgings. The most convincing argument for forgings is the fact that

DRIVING A TUNNEL 600 FEET BENEATH THE HUDSON RIVER WITH THE HELP OF

Lebanon CIRCLE L Steel Castings

700,000,000 gallons of water daily will soon flow through this 7 mile section of the tunnel linking the Rondout and West Branch Reservoirs, an important part of the new 85 mile Delaware Aqueduct being built to bring additional water to New York City.

Only by using the most modern methods and equipment could the Pleasantville Constructors, Inc. have pushed forward a 13½ foot tunnel through solid rock at a rate as high as 109 feet a day for the two headings, an excellent performance.

Much of the modern equipment which helped to make this possible was made from Lebanon Circle L Steel Castings. A part of the drilling equipment embodies Circle L Steel Castings which withstand vibratory shocks. And in air compressors, pumps and car pullers Circle L Steel Castings played an important part.

Wherever equipment must be designed for tougher-than-average service, makers and users have learned that they can rely on Lebanon Steel Castings. Our engineers are trained to help in selecting the right Lebanon Circle L Alloy for your purpose. Consult them.

Drill jumbo, equipped with 6 Ingersoll-Rand DA-35 drifters for heading work in the new Delaware Aqueduct illustrated above. Lebanon's Circle L is incorporated in certain of the mounting parts of these pneumatic rock drills.

STRUCTURAL AND STAINLESS ALLOYS

Circle L Alloys cover a wide range of structural and stainless steels to meet the varying conditions encountered in modern industrial machinery and equipment. Bulletins describing them will be sent upon request.

LEBANON STEEL FOUNDRY
LEBANON, PENNA.

ORIGINAL AMERICAN LICENSEE
GEORGE FISCHER (SWISS CHAMOTTE) METHOD

Lebanon STAINLESS AND SPECIAL ALLOY Steel Castings

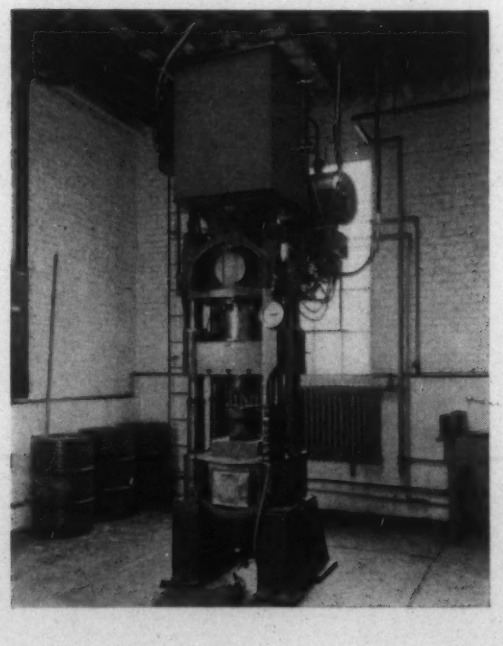
CONTRACT MANUFACTURING BY POWDER METALLURGY

[PRODUCTS PRESSED FROM METAL POWDERS]

WILL SAVE YOU MONEY!

- **Powder metallurgy is often the only answer to tough production problems involving expensive or non-castable materials, close tolerances, excessive machining, etc. —and POWDER METALLURGY INC. is *the one* contract manufacturer to solve them.**

- **POWDER METALLURGY INC. has complete engineering and production facilities for manufacturing — to your specifications — parts and compacts of pure metals, alloys and metal/non-metal combinations.**



"Pomet" alloys afford the advantages of powder metallurgy and can be used to replace many standard brass, bronze, aluminum and iron alloys.

POWDER METALLURGY Inc.

42-41 Crescent St.,
LONG ISLAND CITY, N. Y.

precision hand tools are almost exclusively made of them.

Forgings are employed to a large extent in the manufacture of agricultural machinery. Some of the structures obtained in such forgings and their evident advantages are indicated by J. ROBERTS of Kansas State College ("Flow Lines in Farm Machine Forgings," *Agricultural Engineering*, Vol. 21, Sept. 1940, pp. 346-347, 366). For best results, the flow lines should be carefully controlled to give a smooth, symmetrical fibre with the lines in the right direction. In gears, for example, the flow lines should be parallel to the teeth after milling.

[*In defense of castings, it should perhaps be pointed out that while forgings are doubtless stronger, tougher and more ductile, modern gray cast irons, for example, have been greatly improved in recent years and in some cases approach the strength values of forged steel. Pearlitic malleables often have strength-toughness combinations better than those of steel forgings. Gray iron has an advantageously high damping capacity that makes it attractive for service under vibration conditions —an extremely broad field.*

Costs favor castings where short runs are involved, for forging dies are expensive, but as the number of units of an item to be produced increases, forgings become increasingly attractive. And for many, many articles cost, product quality and shape or size requirements dictate the choice of forgings.—F.P.P.] FPP (3a)

3b. Non-Ferrous

Damping Capacity of Manganese-Copper Alloys

"THE ALLOYS OF MANGANESE AND COPPER—VIBRATION DAMPING CAPACITY." R. S. DEAN, C. T. ANDERSON & E. V. POTTER (Bur. Mines) *Preprint, Am. Soc. Metals*, Oct. 1940, 14 pp. Research.

Certain manganese-copper alloys that possess a remarkable deadness or lack of metallic ring also have unusually high vibration damping capacity at low stresses. The alloys in question contain large amounts of manganese (up to 90% Mn), and the damping capacity varies greatly with mechanical and thermal treatment.

Stable vibration damping capacities (no loss with passing time) were obtained with quenched alloys containing 49.7-90.5% Mn by reheating them at 850°-1100° F. Cold-working of quenched manganese-copper alloys with more than 75% Mn reduces their damping capacity; the as-quenched damping capacity of alloys with less than 75% Mn is relatively low and is not measurably lowered by cold work.

The effect of heat treatment on the damping capacity of alloys with more than 40% Mn is very great, the maximum values being obtained in all but the highest-manganese alloys by reheating at 850° F. These high values are attributed to the formation of ordered anti-phase nuclei in the mass of the alloy. The damping capacity appears to reach a maximum with some critical distribution of these anti-phase nuclei and to decrease as a state of equilibrium order is approached.

There would thus seem to be a similarity in structure with regard to its effect on vibration damping capacity between an alloy in a supercooled state and an alloy in a partly ordered state. In both instances, some of the atoms of the metal are not in the equilibrium positions required by the temperature. High vibration damping capacity appears to be an attribute of such metastable systems. (3b)

Aluminum in the Food Industry

"THE CORROSION OF DIFFERENT GRADES OF ALUMINUM SHEET BY WEAK ACID-SALT SOLUTIONS AND BY AN ALKALINE CITRATE-PHOSPHATE BUFFER SOLUTION IN THE PRESENCE AND ABSENCE OF OXYGEN." J. M. BRYAN & T. N. MORRIS. *J. Chem. Soc., London*, Aug. 1940, pp. 159-162. Research.

Aluminum is used to a large extent by food manufacturers, both in this country and abroad. The commercial grades tested in this study were of 99.99%, 99.8%, 99.5% and 99.6% purity. Corrosive media were 0.5% citric acid + 0.2-2.0% NaCl; 0.5M. citric acid (200 cc) + 0.2M. acid potassium phosphate (200 cc) + *N* sodium hydroxide (350 cc) + additional water to make 1 liter.

The results show that non-oxygenated acid brines (0.5% citric acid + 0.2-2.0% NaCl) do not attack either pure aluminum (99.99) or the less pure grades at room temperature. Non-oxygenated citric acid alone has a slight corrosive effect.

Oxygenated acid brines are corrosive to aluminum. The action is most pronounced on the least pure grade, due to film instability, and is least intensive on the highest purity on account of film protection, although localized attack is possible. Lower sodium chloride concentrations (0.2%) favor more protective films than the higher concentrations. Oxygen has no accelerating effect on the corrosion of aluminum in citric acid alone, although here also localized attack is probable.

Alkaline solutions buffered to pH 10.8 are corrosive to aluminum, depending upon its purity. Oxygen plays a minor role in these solutions. Where it has any effect it is to retard the action. AAA (3b)

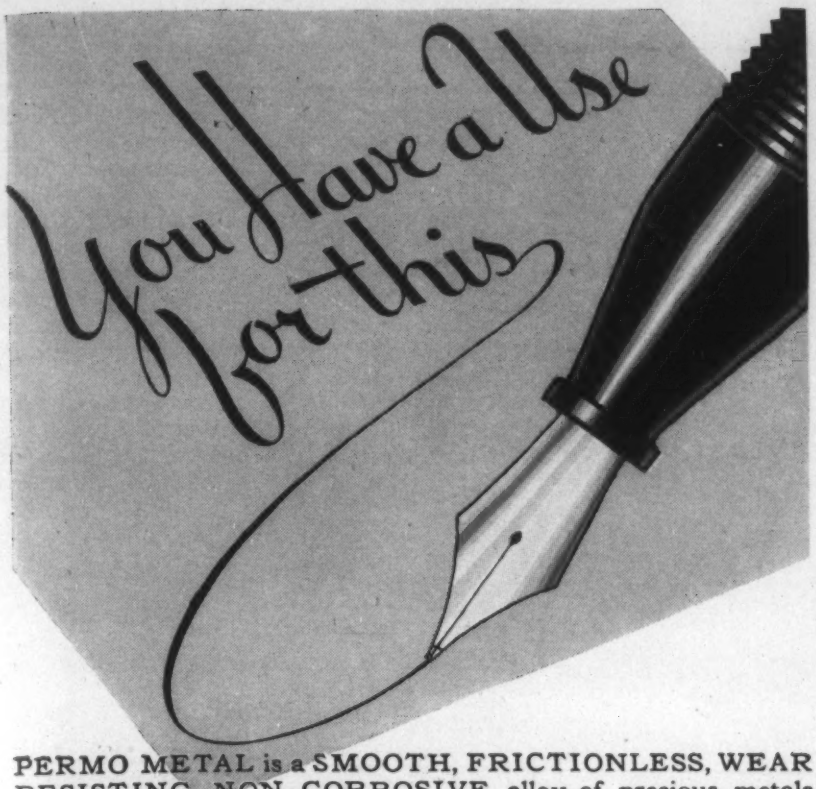
Grain Size and Wear in High-Lead Bearings

"THE INFLUENCE OF CRYSTAL SIZE ON THE WEAR PROPERTIES OF A HIGH-LEAD BEARING METAL." J. R. CONNELLY (Lehigh Univ.) *Trans. Am. Soc. Mech. Eng.*, Vol. 62, May 1940, pp. 309-318. Research.

Lubricated bearings were studied to correlate the "metallurgical" aspects with operating conditions and behavior. Particular attention was paid to the effect on removal of the bearing-metal surface, and on the pressure at which the oil film breaks down, of variations in the crystal structure of the bearing metal, which in these experiments was an alloy of 76% Pb, 15 Sb, 9 Sn. A light turbine oil of 169 sec. at 100° F. was used for lubrication.

The property of the bearing metal that is responsible for a low rate of wear also makes for a high equilibrium pressure and *vice versa*. The rate of wear is taken as the volume of bearing material removed per length of travel of a point on the surface of the cylinder. The crystal structutre is a factor and crystal size an important variable in thin-film lubrication; rate of wear and equilibrium pressure are related and the pressures at the beginning and end of lubricated wear are related.

Under otherwise equal conditions, a very small grain size gives the optimum values of rate of wear and equilibrium pressure. The theory of hydrodynamic lubrication by which at present lubrication phenomena are explained is not yet accurate enough for thin-film lubrication; further developments and investigations of the latter are advocated. Ha (3b)



PERMO METAL is a **SMOOTH, FRICTIONLESS, WEAR RESISTING, NON-CORROSIVE** alloy of precious metals (Osmium, Rhodium, Ruthenium).

Instrument bearings, long life fountain pen tips, phonograph needles and contacts . . . are just a few of countless uses of these remarkable alloys.

A greatly enlarged Metallurgy Division makes these alloys available to industry on an increased scale. An additional service of preliminary assembly of material to holder or shank is also available. Write for detailed data.

PERMO PRODUCTS CORP.
Manufacturing Metallurgists
6425 RAVENSWOOD AVE. PERMO POINT CHICAGO, ILLINOIS

OFHC

OXYGEN FREE HIGH CONDUCTIVITY

A Superior Copper
FOR ALL PURPOSES

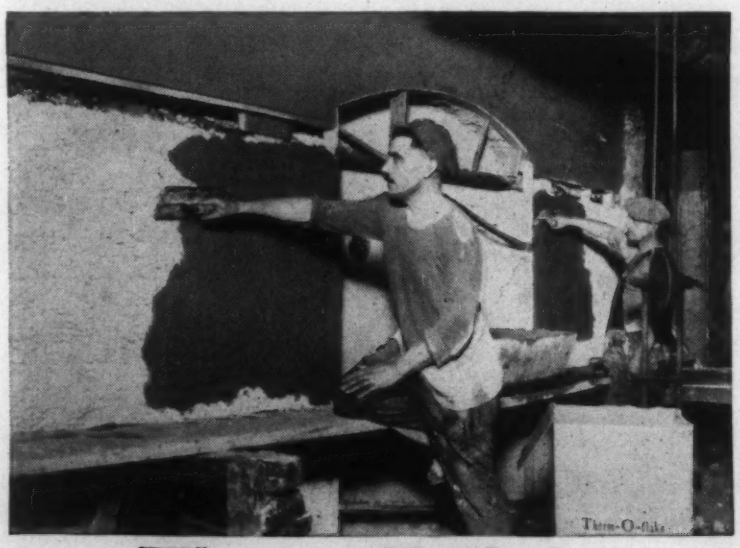
OFHC Copper conforms to the A.S.T.M. Specification for electrolytic copper wirebars, cakes, etc., B5-27 with regard to metal content and resistivity, and is free from cuprous oxide.

OFHC Copper is characterized by its freedom from casting defects and its bar-for-bar uniformity. Its freedom from oxygen results in great ductility and toughness as evidenced by its high reduction of area and resistance to impact.

OFHC Copper withstands more working in hard condition when tensile strength is greatest, making it especially suited for products subjected to severe fabricating or service conditions.

OFHC
REG. U.S. PAT. OFF.

THE SCOMET ENGINEERING CO.
420 Lexington Avenue New York, N.Y.
Formerly
U. S. Metals Refining Co., Oxygen-Free Copper Dept.



Therm-O-flake
COATING

SUPERIOR HIGH TEMPERATURE INSULATION

Keeps heat inside, with a coating of plastic insulation.

One inch thickness equivalent to about nine inches of fire brick wall in insulation value.

More economical in cost and installation, on existing furnaces, than walls of insulation brick.

Easily applied and largely reclaimable for re-use, after removal.

Most widely used material for high temperature insulation, up to 2000°F.

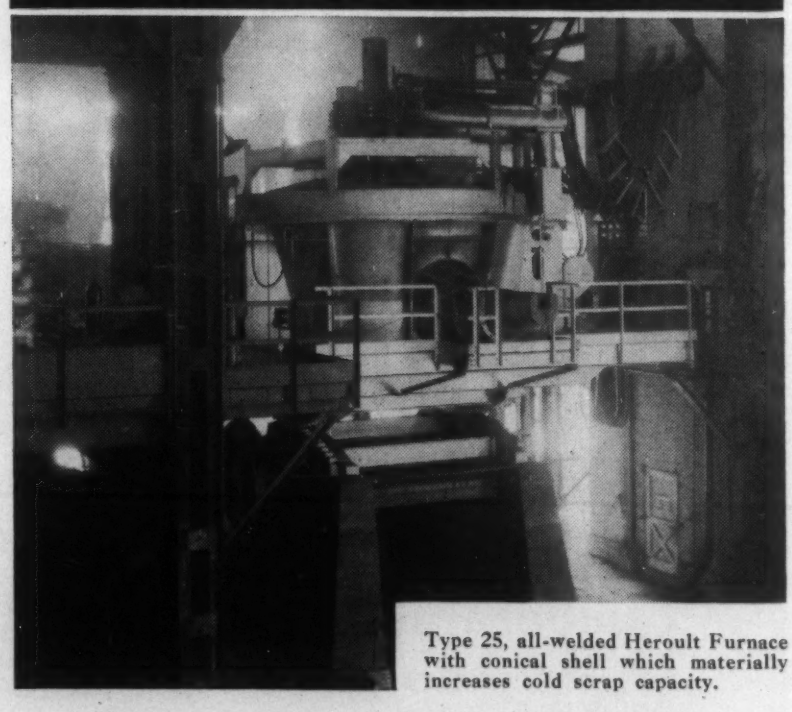
●

Write for Information and Prices

Other Therm-O-Flake Products
● Made from Exfoliated Vermiculite
Granules, Brick, Block, Concrete

Illinois Clay Products Company
JOLIET, ILL.

Heroult ELECTRIC FURNACES



Type 25, all-welded Heroult Furnace with conical shell which materially increases cold scrap capacity.

For low-cost, efficient melting and refining of all kinds of ferrous materials by either basic or acid process—including alloy, tool, and forging steels, iron and steel castings. Any capacity from ½ ton to 100 tons; hand, chute, machine or drop-bottom bucket charging.

AMERICAN BRIDGE COMPANY

General Offices: Pittsburgh, Pa.
Offices in the larger cities
Columbia Steel Co., San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL

4 Testing and Control
METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

Welding Instrumentation

"Instrumentation of Arc Welding." Robert E. Kinkead. *Welding J., N. Y.*, Vol. 19, Sept. 1940, pp. 651-653. Descriptive.

A man with a stop watch and the usual time-study methods, but without a background of welding knowledge, can get management into a great deal of trouble in a very short time in setting up systems for paying bonuses.

More than 95% of all arc welding is carried out manually and some of the factors that affect operator production have been studied. For instance, it has been shown that in a confined space 30-35% less metal per hr. will be deposited by the operator than if he is in an open space. The speed of production is reduced 80% in many cases by changing from straight down to vertical or overhead welding; other production-speed factors are the length of welding rod, and the use of suitable holders or shields.

Important among the instruments used for studying operator performance is a timer for recording accurately the time the operator has the arc in normal operation. Another instrument shows the time of normal arc operation of the manual operator and the time in which he had the arc in operation, but was not operating the arc in a normal manner. This instrument is used in a study of position-welding and operator fatigue. An instrument used in training beginners consists of a shield that flashes a red light for abnormal arc conditions and green when normal. WB (4)

Testing Cast Iron for Fatigue and Impact Strengths

"The Fatigue and Impact Strengths of Cast Iron." J. W. Donaldson. *Foundry Trade J.*, Vol. 63, Aug. 8, 1940, pp. 91-93, 96. Up-to-date review.

Fatigue tests on cast materials for crank shafts show that in comparing similar materials having the same Young's modulus, the usual limiting fatigue stresses may be employed as the basis of comparison, but in the case of cast iron, where varying values of Young's modulus are obtained, it may be better to base such comparison on the limiting fatigue distortions. This may be done by measuring both the limiting fatigue stress and Young's modulus and assessing the merits of the two materials by the ratios of these two properties.

For the cast iron tested, the limiting fa-

HIGH TEMPERATURES

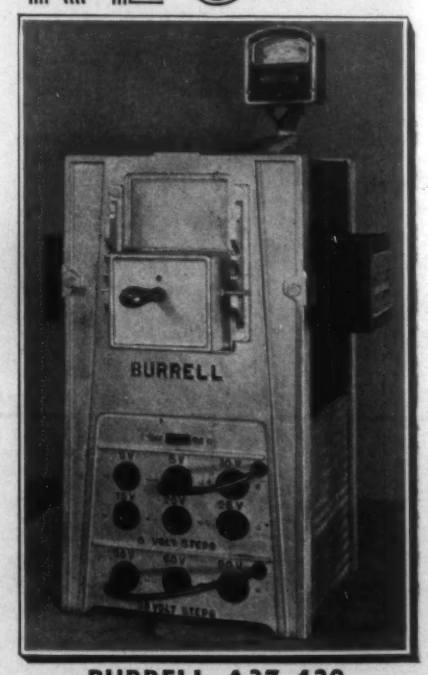
for testing purposes---

The New LITTLE GIANT

Temperatures up to 2500° F.

- Big Chamber, 4" w. —3½" h.—7" d.
- Built-in Transformer and Control Panel
- Quick Change Elements (115/230 v.)
- Rack Type Door
- Pyrometer Optional

Ask for Bulletin 40-96



BURRELL A37-420

Everything but pyrometer—only $195.

BURRELL TECHNICAL SUPPLY COMPANY
1936-42 FIFTH AVENUE « « « « « « « « « « PITTSBURGH, PA. U.S.A.

RADIUM

Courtesy Lebanon Steel Foundry

The quantity of radium used for industrial radiography is in units of from 25 milligrams to 500 milligrams. The silver capsule containing the radium is placed inside a duralumin container to facilitate ease in handling.

●

The only other equipment necessary is x-ray films and lead foil intensifying screens which are placed on both sides of the film within the film holder.

●

Note!

In the above illustration, the radium is in the center surrounded by eleven steel castings. One exposure takes eleven radiographs. The exposure time varies inversely with the amount of radium used, therefore the exposure required when using 200 milligrams is one-half the time when using 100 milligrams.

IN the gamma-ray radiographic set-up, the film holders are placed on the metal face opposite to the radium. The castings can be placed entirely surrounding the radium, as well as above and below. In practice the distance from the radium to the film depends upon the number and size of the castings to be radiographed at one time and upon the definition desired. Radium for non-destructive testing may be rented at very small cost.

Write for Details

RADIUM CHEMICAL COMPANY Inc.

570 Lexington Ave., New York

Chicago: Marshall Field Annex Building

tigue stress was approximately 15,000 lbs./-in.^{2}, and Young's modulus 17.7×10^{-6} lbs./-in. A "typical" steel will have a limiting fatigue stress of 44,000 lbs./in.^{2} and a Young's modulus of 30×10^{-6} lbs./in.^{2}, so that the ratio of limiting fatigue distortion of steel to that of iron is 1.68, while the ratio of limiting fatigue stress is 2.86. The first comparison shows the cast iron in a much more favorable light than does the second. This fact is important in crankshafts, where strain is a function of the amount of distortion of the shaft rather than of the application of a definite bending moment.

During recent years, the British Cast Iron Research Assoc. has adopted the Krupp-Stanton repeated impact test for the impact testing of cast iron. This test can be made to approach either a single-blow test on the one hand or a fatigue test on the other by varying the weight and height of fall of the weight, and the test used by the Cast Iron Research Assoc. is adopted to co-ordinate both these extremes. This test, although it gives fairly satisfactory results for the impact resistance of cast iron, is not very suitable for routine work, since the specimen is not simple to prepare and the time taken to determine the impact strength of some irons is considerable.

A single-blow test has therefore been developed by the Association using the standard Izod machine with a special vise and a 0.798 in. diam. unnotched test-bar. The values obtained for the repeated-blow test show that there is a wide range in such tests and that more uniform results for all the irons are obtained from the single-blow test. There is little direct relationship between the impact strength and the tensile strength, as a pearlitic iron with a good tensile strength has a low impact value, and an austenitic iron with low tensile strength a much higher value on a single blow test.

It has been suggested that the impact strength of cast iron depends on its ability to deform plastically under load, and as the plastic property is constant at about 25% of the total deformation at fracture, the impact value of cast iron will increase with the strength, provided the plastic value does not vary from normal. In austenitic cast irons, where the plastic value is high, a high resistance to single impact is obtained, and high-strength cast irons of relatively poor plastic properties usually show low impact values.

Piwowarsky (METALS AND ALLOYS, Vol. 8, June 1937, p. MA 368 R 2) demonstrated that the impact strength of cast iron is related to the type or test-bar selected and the distance between the supports, and that a test bar having a cross-section of less than 1 cm.^{2} is not suitable for determining the impact strength of bars in the as-cast condition. The speed of the blow has a considerable influence. [*Repeated stresses remove the plastic component and elastic resistance is then the major factor. A single blow test is relatively favorable to a weak iron because all of the plastic component is additive to the elastic in such a test.—J. W. B.*] AIK (4)

"ROCKWELL"
Superficial
HARDNESS TESTER

for Sheet Metal

Most of the sheet metal, ferrous or non-ferrous, wherein hardness is important, whether for automobile fenders and bodies, telephone apparatus, loose-leaf binders, clocks, dental material and innumerable other purposes, is having its hardness determinations made on the "Superficial."

The "Superficial" though designed for very shallow indentations, and highly sensitive, is as speedy, sure and convenient to use as the normal "ROCKWELL" Tester.

743 E. 143rd Street
New York

WILSON
MECHANICAL INSTRUMENT CO., INC.

Thickness of Anodized Films

"ELECTRICAL BREAKDOWN OF ANODICALLY OXIDIZED COATINGS ON ALUMINUM: A MEANS OF CHECKING THICKNESS OF ANODIZED FINISHES." K. G. COMPTON & A. MENDIZZA (Bell Tel. Labs.) *Preprint, Am. Soc. Testing Materials,* June 1940, 10 pp. Descriptive.

The existing methods for determining the thickness of anodically produced oxide coatings on aluminum are relatively few and are almost entirely of a destructive nature. On the other hand, it is a fairly well established fact that, within the thickness limits normally encountered in practice, the voltage breakdown is a linear function of thickness of oxide film. The authors have utilized this fact in developing a test method for determining the thickness of coatings produced under known and controlled conditions with practically no injury to the finish.

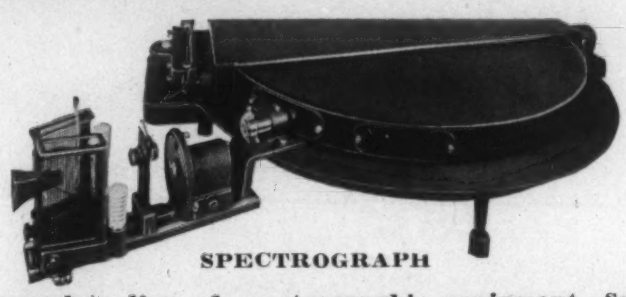
Data are given to show the relationship between breakdown resistance, anodizing time, thickness of coating, current density and sealing of anodically oxidized polished commercially pure aluminum. Statistical data for the values obtained are also given, indicating the good reproducibility of the breakdown values. By calibrating a particular anodic process, satisfactory results may be obtained in a relatively short time and often without destroying or marring the article. Since the oxide coating is not entirely homogeneous it is necessary to obtain a fairly large number of readings for every test condition. Twenty-five readings are usually sufficient and can be made in a relatively short time.

This method is now used as a routine test for checking the thickness of aluminum oxide coatings. For general work a rough factor of 93 v. per 0.0001 in. has been used. Values obtained are well within 10% of the values obtained with the microscope. Care must be taken to avoid measurements too near the edge or at some point where the coating has been subjected to bending. VVK (4)

MODERN ANALYSIS

Carbon Determinator

Carbon and sulphur determinations may be made within six minutes after the molten metal is taken from the furnace. Accuracy is not sacrificed for speed. The molten metal is poured into the Specimen Mold. The resulting test specimens are weighed and placed in combustion boats for carbon and sulphur determinations. The carbon is determined accurately by combustion-volumetric method and the sulphur by the combustion-titration method.



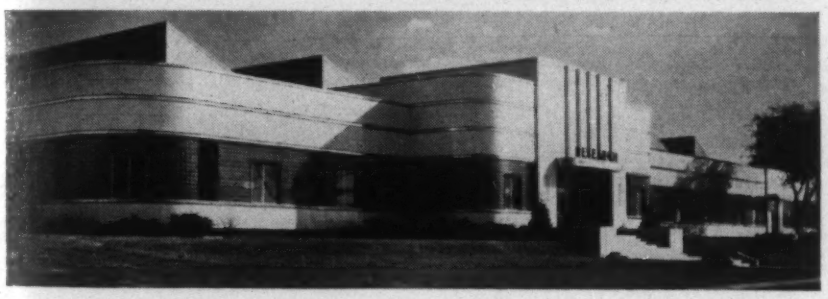
SPECTROGRAPH

A complete line of spectrographic equipment—Spark Source Unit—D.C. Arc Source Unit—A.C. Arc Source Unit—Densitometer for 4" x 10" plate or film spectrogram—Plate or Film Dryer—Plate or Film Developing Machine — Calculating Board—Specimen Mold — are available. Spectro-chemical analysis of metals can be made within plus or minus 2%.

Write for details.

HARRY W. DIETERT CO.

9330-B Roselawn Avenue Detroit, Michigan



IN THE WORLD'S LARGEST PORCELAIN ENAMEL BUILDING

The new research laboratory of The American Rolling Mill Company at Middletown, Ohio, is "all-electric" and is said to be the world's largest porcelain enamel building.

Experimental heats of iron and steel are melted down in small Ajax-Northrup High Frequency Furnaces with current supplied by a 35 KVA Ajax-Northrup Converter.

For larger melts they use Ajax 250 and 500 lb. furnaces and a 100 KW high frequency motor generator.

Accurate control, flexibility and the fact that a large number of test melts can be made in a comparatively short time are the principal advantages of the Ajax-Northrup Furnace.

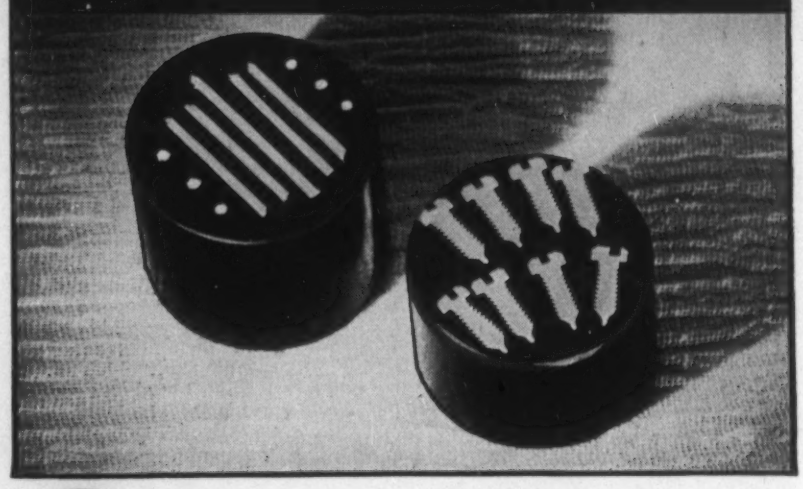
ASK FOR BULLETINS T-5 AND T-6.

Ajax-Northrup Melting Furnace Capacities: One Ounce To Eight Tons

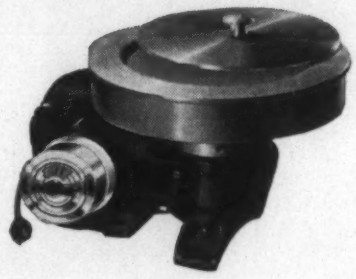
AJAX ELECTROTHERMIC CORPORATION
AJAX PARK
TRENTON, N. J.

AJ-23-A

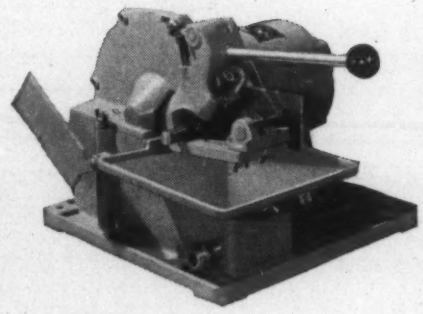
IN METALLURGY . . .



AB SAMPLE PREPARATION EQUIPMENT IS USED EVERYWHERE

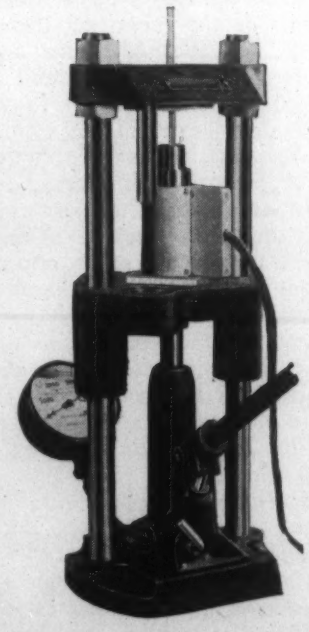


AB STANDARD AND LOW SPEED POLISHERS are available with LEAD DISC ASSEMBLY for extreme accuracy in flatness to retain graphite inclusions. THE MECHANICAL HOLDER saves time and polishes 1 to 6 specimens simultaneously.



AB SPECIMEN CUTTER offers safe and cool cutting of specimens. Perfect radial and axial alignment, efficient design and craftsmanship make this Cutter an indispensable tool for the Metallurgist.

AB SPECIMEN MOUNT PRESS avoids differential etching action, relief polish, margins, and crevices with plastic mountings in bakelite or the transoptic way. It saves time and is economical.



POLISHING STANDS
STRAIGHT LINE GRINDERS
PAPER DISC GRINDERS
SPECIMEN STORAGE CABINETS

ASK FOR YOUR COPY OF "THE METAL ANALYST"

Adolph I. Buehler

OPTICAL INSTRUMENTS • METALLURGICAL APPARATUS
228 NORTH LA SALLE ST. • • CHICAGO ILL.

Government Orders

Meeting strict physical specifications is facilitated by the use of Scott Testers, while the resulting file of picturized charts furnishes valuable data for future reference, in a "language" used by leading laboratories and technical societies the world around.

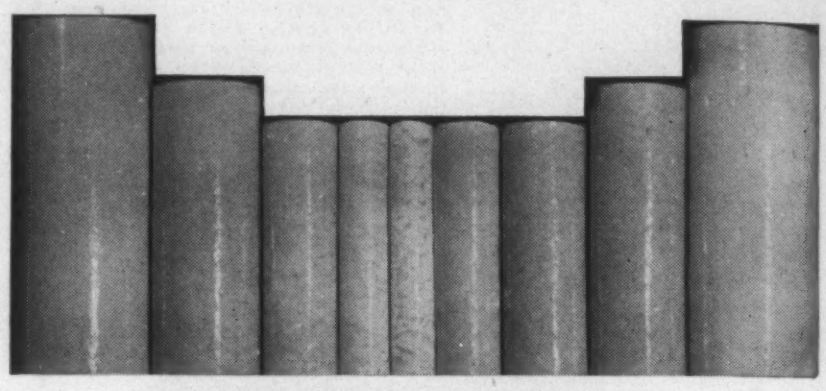
SCOTT TESTERS
TRADE MARK

Henry L. Scott Co.

Providence, R. I.

LARGE VITREOSIL PIPES

(Vitreous Silica)



Internal diameters up to 30 inches
Lengths up to 10 feet
Indifferent to Extreme Chemical, Electrical and Thermal Conditions
Low Permeability to Gases
For Continuous Use up to 1000-1100°C

FOR
SINTERING
CHLORIDIZING
HEAT TREATMENT OF METALS
HIGH-VACUUM PROCESSES
CONTROLLED-ATMOSPHERE TECHNIQUES

Let Us Help with Your Problems

THE THERMAL SYNDICATE, LTD.

12 East 46th Street New York, N. Y.

High Temperature Tension Tests

"High-Speed Tension Tests at Elevated Temperatures." M. Manjoine & A. Nadai (Westinghouse Elec. & Mfg. Co.) *Preprint, Am. Soc. Testing Materials,* June 1940, 16 pp. Descriptive.

Very little is known about the actual forces required to deform copper, steel, or some of the other ductile metals at very high velocities of strain and at elevated temperatures. A high-speed tension testing machine was developed in which the tension diagrams of metals were recorded.

The test specimens occupied the axis of a copper coil which served as an induction furnace, in which temperatures up to 2200° F. could be reached. The tension tests were carried out at an approximately constant relative velocity between the heads. Stress-strain curves were automatically recorded on the screen of a cathode-ray oscillograph, using the elastic strain in a very rigid steel bar as a means for the indication of the load, and the relative movement of the heads of the specimens for determining the strains. Nineteen specimens of soft annealed copper were tested at three rates of strain—135, 450 and 900 per sec. —and at 400°, 750°, 1125° and 1475° F. At a strain rate of 135 per sec., tests were also made at 1650° and 1830° F. (The results on tests with steel and other metals will be reported elsewhere.)

From the evidence available it seems that the trend of the curve representing the general speed law of plastic deformation at a given temperature is characterized by an inclined straight line in the semi-logarithmic plot at the intermediate range of speeds. This curve bends off at both ends of this intermediate range. VVK (4)

Microradiography

"The Technique of Microradiography and Its Application to Metals." G. L. Clark & W. M. Shafer. *Preprint, Am. Soc. Metals,* Oct. 1940, 19 pp. Research.

Because it is impossible to magnify X-ray images in the same sense that optical images are magnified by suitable lenses, it is necessary to register the X-ray image on a photographic plate and then enlarge the photographic image. By the use of the Lippmann-Gevaert emulsion with extremely fine grain size for the silver halide a magnification up to 200 may be made without loss of detail from graininess.

A successful radiograph also depends upon the choice of X-ray wave length that will give a maximum differentiation between constituents in a specimen such as aluminum and copper in an alloy. In this paper the theoretical absorption equations are developed leading to a simple and practical technique for metals. Instead of employing very soft X-rays at a few thousand volts with attendant prolonged exposure time, very successful results were obtained with characteristic X-rays of molybdenum, copper and iron as produced in ordinary diffraction apparatus.

A camera for multiple exposures is described and results are reported for copper-aluminum alloys, brass, type metal and graphitic steel. As a supplement to the microscope, microradiography has great metallurgical usefulness with the advantages that it gives a three-dimensional view of a specimen, does not depend upon differential action of etchants but only on different absorbing power of constituents or inclusions, is directly interpreted, reveals internal voids and cracks, and requires no special polishing or preparation of the specimen. (4)

New Constant for "Proof Stress"

"New Constant to Replace Proof Stress." *Light Metals,* Vol. 3, Sept. 1940, pp. 225-226. Discussion.

As is well known, there is no uniformity of practice in regard to choice of the amount of total deformation used to determine proof stress or yield strength in the tensile test. Because of the arbitrary nature of the conception of proof stress, it is not necessarily directly related to any inherent property of the material being tested.

It is suggested, therefore, that the stress-strain diagram be plotted on logarithmic coordinates. If this be done, the stress-strain curve resolves itself into two straight lines intersecting at a point usually not far from the 0.2 or 0.1% offset stress value (proof stress or yield strength). Because this point of intersection, called *bend-point stress*, is a natural feature of the stress-strain diagram plotted in this manner, it is suggested that it might logically replace proof stress as a measure of the point where marked permanent deformation sets in.

From results on a number of different materials tested in tension with an extensometer reading to 0.001 mm., it was found that the bend point always occurred below the 0.2% yield strength, and sometimes below the 0.1% yield strength. Among the materials tested were pure hard drawn aluminum; aluminum alloy with 4.76% Cu, 0.79 Si and 0.12 Mg; brass with 38.4% Zn and 2.35 Pb; electrolytic copper; and certain steels. AUS (4)

TOUGH AXLES FOR TOUGH LOADS

Autocar trucks have a long record of successful service. Famous for their endurance and adaptability to difficult jobs, they are found everywhere in industry and commerce, "pulling the tough loads."

Autocar truck axles are made of TIMKEN Alloy Steel.

"Follow the leaders"—and you'll buy TIMKEN Steel. Consult us without obligation.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

Steel and Tube Division

Manufacturers of TIMKEN Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; TIMKEN Alloy Steels and Carbon and Alloy Seamless Tubing; and TIMKEN Rock Bits.

TIMKEN
ALLOY STEELS

books

Industrial Uses of Silver

SILVER IN INDUSTRY. *Edited by Lawrence Addicks. Published by Reinhold Publishing Corp., New York, 1940. Cloth, 6 x 9 in., 636 pages. Price $10.00.*

The purpose of this volume "is to further the industrial application of silver by recording what has already been accomplished and pointing out likely lines of advance." The book also constitutes an excellent reference work and handbook on the properties of silver and its alloys and as such should be most useful to metallurgical engineers.

The reason for the search for industrial uses will be clear from the following extracts from the July 17, 1940, issue of *Poor's Industry and Investment Survey:*

> POLITICS PROTECT SILVER
>
> Both domestic and foreign silver prices continue under the protection of the powerful group of "Silver Politicians" in Washington. . . . Since the Silver Purchase Act . . . has dislocated the world position of silver, the outlook for the metal cannot be considered bright. . . . Sooner or later it is reasonable to expect that the American public will strongly express its opposition to our further sole support of the metal's position, and such a development will result in a sad awakening to both domestic and foreign producers. . . . Accordingly, investors holding equities of companies with important stakes in silver are placing their trust in the "American Silver Bloc," and this dependence upon politics does not appear to be an advisable one.

Ten firms, silver producers or fabricators of silver, foreseeing that the time will come when the U. S. Treasury will no longer pay an artificially high price for silver, so that a free market for silver is in the offing, banded together for research to appraise the situation as to industrial uses for silver. Present industrial uses take but a small fraction of the production and the situation is aggravated by the fact that two-thirds of the production comes as a by-product from complex ores smelted for lead, copper or zinc, so it piles up whether it is wanted or not. "Industrial consumption," says Addicks, "is the only refuge".

The cooperative research to find industrial uses was extensive rather than intensive. As soon as any use was developed far enough so that there was any hope that industry would continue research on its own hook, that phase was dropped like a hot potato. No patents were sought. The account of the research work, supplemented by information from the literature, is therefore very patchy, held together only by the fact that it is all about silver, and, since each section was written by those most concerned with that phase of the work, the styles vary widely, from the free-flowing one of Addicks himself to those resembling a laboratory note book.

But, in one form or another, the lion's share of what is known about the properties and usefulness of silver is here. Chapters deal with properties; binary alloys; ternary and complex alloys (including new experimental work of a sketchy character); technology (mechanical properties); low-temperature bonding (which has some relation to powder metallurgy); high temperature bonding (silver-clad metals and silver brazing); silver bearings; coatings in general; electroplated coatings, including deposited alloy coatings; chemical and vaporized coatings (mirrors, sealed-beam auto headlights, etc.); electrical contacts; moving electrical contacts (brushes and collector rings, mostly experimental); chemical catalysts; corrosion resistance, including tarnishing, with an over-optimistic appraisal of the scheme of Price and Thomas; oligodynamic (germicidal) effects, with comments on physiological and biological effects; fungicidal effects (plant sprays); miscellaneous (sterling, photography, medicine, dentistry, etc); and statistics of industrial consumption (including discussion of scrap return).

In the summary, it is stated that metallurgical uses (as distinguished from chemical, germicidal, etc.) offer the greatest hope for increased consumption, with use as protective coatings for containers for chemically active materials as the brightest spot.

Over 125 pages of bibliography and 15 pages of patent references, collected under many headings, add greatly to the usefulness of the volume, which is also well indexed.

The book is very much worth while. Its preparation was a major task effectively carried on chiefly by Dr. Dornblatt in the midst of many other duties, and to him goes much credit for so effective a job.—H. W. GILLETT.

Engineering Materials

PROPERTIES OF ENGINEERING MATERIALS. *By Glenn Murphy. Published by International Textbook Co., Scranton, Pa., 1940. Flexible binding, 5½ x 8½ in., 387 pages. Price $3.50.*

This is an introductory text for engineering students, not a handbook, and is used at Iowa State College. It is more concerned with creating the proper viewpoint than with citing a lot of data. The author points out at the start that durability, appearance and economy are all factors in the choice of materials, that testing should be approached from the consideration of the different causes of destruction in an effort to evaluate resistance to each separately, and then to appraise the material from those data plus the lessons of experience.

In the beginning of the chapter on behavior under load it is emphasized that actual stress distribution is likely to be very different from that assumed by theory. Stress concentration, fatigue and creep are brought up early. These discussions are extremely good in giving the young reader a sound and realistic point of view. Too few textbooks either strive to, or do, accomplish this.

The later sections of the book cover the usual material; the heat treatment of steel and the manufacture of steel, cast iron and wrought iron are briefly sketched. Shaping operations are mentioned and S.A.E. steels discussed. The chief non-ferrous metals and their alloys are dealt with in much the same fashion. Timber, stone, clay products, cement, concrete and plastics then get brief attention.

The metallurgical discussions are elementary, but generally satisfactory as far as they go. It might have given a little better perspective in these sections if welding and zinc-base die castings had been featured rather than just mentioned, and if high-yield-strength low-alloy steels had been mentioned. A few cases of failure to give a true perspective appear. Under "production of special steels" it is stated that the three processes in most common use are the cementation, the crucible, and the electric furnace processes.

Also, terming iron-carbon alloys of 1.7-2.2 per cent C—between steel and cast iron —"semi-steel" is not helpful.

On the other hand it is a relief to have a textbook admit that cast iron can be had up to 60,000 lbs. per sq. in. tensile, and to point out something about warping and cracking of steel from quenching stresses.

A large number of problems and review questions are appended, aimed to make the students think. For its particular purpose, this book is excellent.—H. W. GILLETT.

(Continued on page 706)

Even We Were Surprised

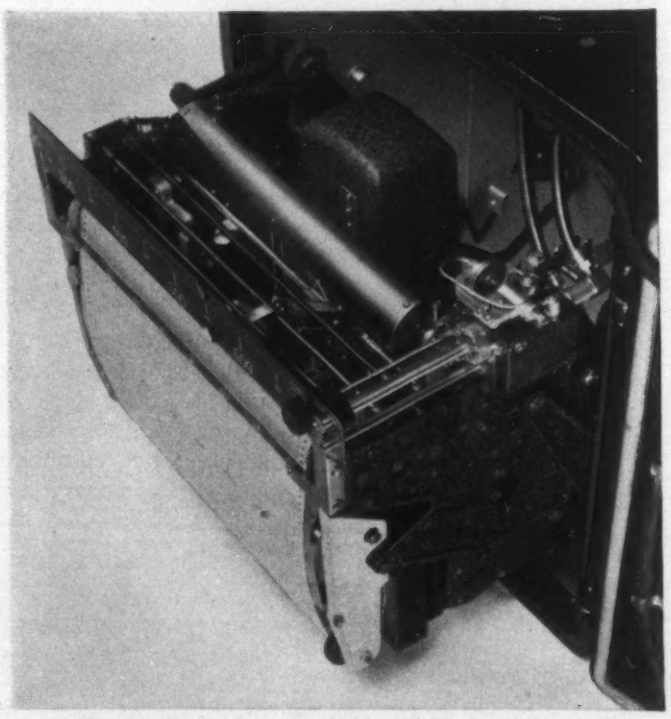
AT THIS PROOF OF DEPENDABILITY!

One large industry reports a cut of more than 50% in spare-parts inventory after switching to Foxboro Potentiometer Recording Controllers

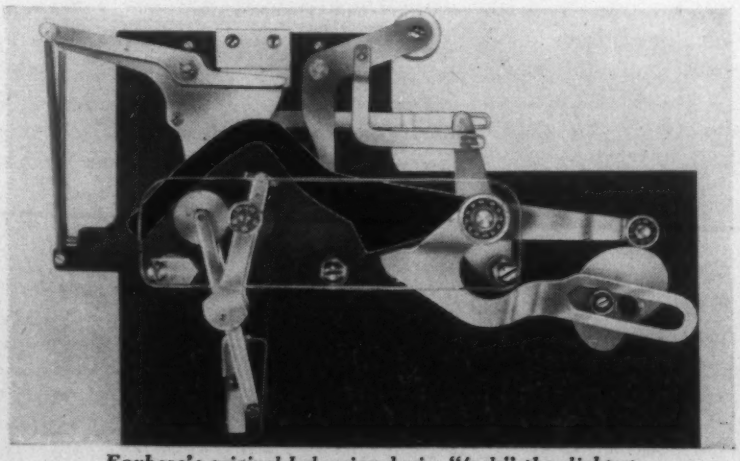
Did you ever think of spare-parts inventories as a measure of dependability in instruments? We never did, either, until numerous reports of this kind came from users of Foxboro Potentiometer Recorders and Recording Controllers. Due to decreased repair needs, one manufacturer was enabled to *halve* his inventory!

Look at the mechanism, and you'll see why . . . also what this means in terms of continuous, dependable instrument performance. Notice how Foxboro's original automatic balancing device produces fast balancing without fast driving of the mechanism . . . how the unique integral mounting of slide-wire contact and recording device eliminates gearing and "transmission errors."

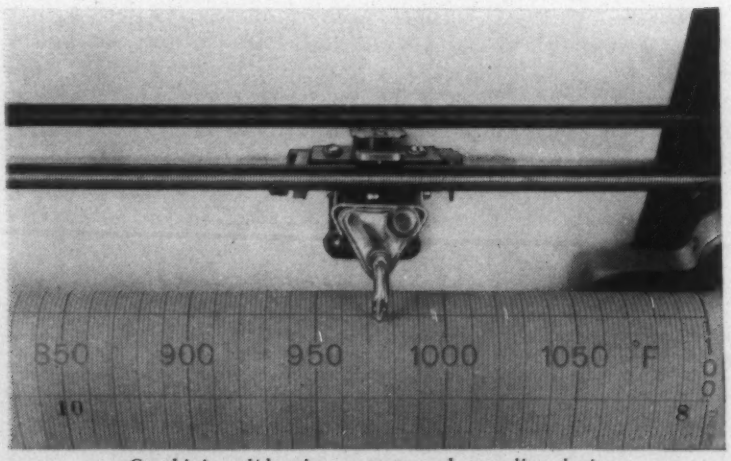
These exclusive Foxboro features provide instant, accurate response with *slower* movement of elements, and *fewer* moving parts to wear out! They furnish a new high degree of sensitivity combined with practical freedom from maintenance. Write for detailed booklet 190-4. **The Foxboro Company, 54 Neponset Avenue, Foxboro, Mass., U. S. A.** Branches in 25 principal cities.



The entire Foxboro mechanism pulls forward out of case for easy servicing. Exclusive rubber-cushioned mounting within case damps out vibration.



Foxboro's original balancing device "feels" the slightest galvanometer change . . . stops lost motion . . . gives guaranteed accuracy of ¼ of 1% of scale range.



Combining slide-wire contacts and recording device in this simple assembly, Foxboro Recording Potentiometer Controllers eliminate transmission errors.

FOXBORO
REG. U. S. PAT. OFF.

RECORDING POTENTIOMETER CONTROLLERS

(Book Reviews) from page 704

Superfinish

THE STORY OF SUPERFINISH. *By A. M. Swigert, Jr. Published by Lynn Publishing Co., 5106 Buckingham Rd., Detroit, 1940. Cloth, 6 x 9 in., 672 pages. Price $5.00.*

"Superfinish" is the term applied to a Chrysler-developed fine finishing process—an oil-stoning operation, with long strokes and low pressure, by which 0.0001-0.0003 in. is removed from the surface of a wearing part, to cut off the projections or fuzz left from earlier finishing operations, usually fine grinding. The depressions left by the scratching in the earlier operations are not removed in the usual superfinish operation, and the tiny scratches from this operation itself are, in general practice, randomly oriented. This book, profusely illustrated and written in non-technical or only semi-technical style, sets forth all the arguments that can be marshalled for the benefit of smooth surfaces, and of this particular method of producing them.

If the elimination of the very tiny depth of fuzz prior to assembly instead of letting it wear off during the "wearing-in" of the mating parts is as much of an improvement as the author and his colleagues in The Chrysler Corp. believe, the book is a missionary treatise. If it is not highly important or if other methods will serve, then it is propaganda. The book is, unfortunately, based on the possibly true but insufficiently-proved assumption that maximum smoothness is the only sensible condition; quantitative engineering proof in cold figures, supplementing the large amount of mere argument is extremely scarce.

No discussion is given of the cases where a less smooth finish is adequate or preferable, save that it is admitted that a burnished surface will do for a pressed fit. The capitalization of the whole word "Superfinish" whenever it occurs is likely to irritate most engineers. A more impartial engineering attitude would have avoided the reader's constant feeling that the book is a piece of special pleading.

The papers and discussions at the recent M.I.T. conference on surface finish, which raised some question whether commercial superfinish is the ideally smooth surface described in the book, should be read, when they are published, at the same sitting as this book so that a more calm and unbiased appraisal can be made than results from merely absorbing the religious ardor of this book. If the reader will regard it as a lawyer's brief for one side, sometimes shrewdly over-stated, he can accept and profit by the clear presentation of the bulk of the discussion and discard the doubtful portions.

Since the main application of superfinish is on shafts and other bearing surfaces, bearings and lubrication are discussed at length in generally helpful fashion. Qualitative comment is made on surface finish vs. fatigue, but no evidence is produced to show whether superfinish helps. This omission, and the fact that earlier grooves are not removed, probably mean that no detectable improvement is produced.

In this connection the author says, "railroad men have long been conscious of the part that smooth surfaces play in preventing fatigue failure of engine and car axles." Maybe they have been conscious of it, but they haven't done a whole lot about applying that information.

Superfinishing is supposed to remove the fragmented "smear metal" produced by cold working and burnishing effects of previous operations, with great emphasis on the cutting rather than burnishing in the final operation. The use of readily work-hardenable 18 and 8 stainless steel to supply evidence is none too convincing as to the effect in the steels actually used.

Beilby's "amorphous metal" hypothesis is strongly featured, but with sufficient hedging as to the definition of amorphous and sufficient use of the more accepted term, "fragmented layer," to take the curse off somewhat. However, it is certainly going too far to make the statement (on page 519) that workers in electron diffraction conclude that not only is there an amorphous layer on the surface of polished metals, but also in grain boundaries and along slip planes. Electron diffraction is quite incompetent to establish anything about the grain boundaries.

The book gives very readable discussions of all the methods of measuring surface roughness, and of the way various machining and grinding operations are carried out, as well as of superfinishing itself. The treatment of lubrication is, however, the high spot of the book.

Even though the missionary-propaganda flavor is too strong, the style might well be observed by engineering writers. A more happy mean between being interesting, as this book is, and using a formally cold-blooded engineering style, not only without bias but without human interest, would be a big improvement.—H. W. GILLETT.

Aircraft Encyclopedia

AEROSPHERE, *1939. Edited by Glenn D. Angle. Published by Aircraft Publications, New York, 1940. Cloth, 9¼ x 12 in., 1420 pages. $15.00.*

This is a remarkable publication. Its issuance during this period of rapidly ascending importance of the aircraft industry is more than timely, but the real value of the volume lies in the evidently comprehensive and accurate manner in which it describes the various aircraft engines and aircraft of manufacturers all over the world. In one respect it appears to be a competitor of Jane's "All the World's Aircraft," but is twice as large as the latter.

The book is divided into 4 main sections: Aircraft engines, aircraft, aircraft statistics, and a trade directory with a supplementary "product listing" covering firms and organizations that make up the aviation industry throughout the world.

The largest section is that on aircraft engines, comprising 844 pages and over 1500 illustrations, and is intended to serve as a ready reference for anyone interested in aircraft engine design and construction. Many of the details of the design of engines, from small 2-cylinder jobs to giant air-cooled and liquid-cooled plants for the world's largest commercial and military planes, are of great interest to metallurgical engineers, for the metals and metalforms used for cylinder barrels, heads, crankshafts, pistons, bearings, pumps and blades, connecting rods, etc., etc. are indicated in many cases, with additional metallurgical-design data on methods of linking, finishing, assembling, etc.

Likewise in the smaller section (200 pages) on aircraft there are many data on individual plane design with respect to fuselage materials, structure (monocoque, welded tubing, etc.) and assembly method, wing materials and covering, tail-group materials and design, etc. of interest to readers of this magazine.

The sections on statistics and trade structure are of obvious value, and make complete the utility of an already highly valuable volume.—FRED P. PETERS.

Corrosion of Ferrous Metals

THE CORROSION OF IRON AND STEEL. *By J. C. Hudson. Published by D. van Nostrand Co., New York, 1940. Cloth, 5½ x 8½ in. 319 pages. Price $5.75.*

Extensive cooperative research on corrosion of iron and steel has been carried on in England, and has been recorded in progress reports published by the Iron and Steel Institute. This book summarizes the work to the fall of 1939 in elementary style, using phraseology such that it doesn't take a corrosion expert to follow it.

Chapters deal with effect of rolling scale, rusting of bare steel in the air, painting, other protective coatings, rusting in sea water, rusting in miscellaneous environments, fundamental studies of corrosion, etc.

Copper, in copper-bearing steel, was of course found beneficial against atmospheric corrosion. Fragmentary tests indicated that arsenic may be helpful. Ferrous phosphate-phosphoric acid baths after pickling and before painting, or washing down the steel with weak phosphoric acid before painting were indicated to be advantageous.

A good many practical service tests were made. One of them slipped up. The program called for study of steel plates of various compositions above as well as below the water-line of H.M.S. *Bassett*. It turned out that the men of His Majesty's Navy keep their ships painted above the water line, and experiment or no experiment, the *Bassett* was thus kept painted.

The corrosion expert who has followed the progress reports as fast as they appeared will not be greatly impressed by this volume, which hits only the high spots and lets the details go. The engineer and executive will, however, find the book useful, and rather easy reading.—H. W. GILLETT.

Other New Books

A BIBLIOGRAPHY OF INDIUM, 1934-1940. *By Maria Thompson Ludwick. Published by Indium Corp. of America, Utica, N. Y., 1940. Paper, 7 x 10 in., 22 pages.* An evidently complete source-list of material on indium published throughout the world in the last 6 years, with over 300 references covering occurrence and extraction, properties, alloys, uses, chemistry, etc.

TRANSACTIONS, AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, VOL. 137. (INSTITUTE OF METALS DIVISION). *Published by the A.I.M.E., New York, 1940. Cloth, 6¼ x 9¼ in., 487 pages. Price $5.00.* Papers and discussions on non-ferrous topics presented at A.I.M.E. meetings at Chicago, October 1939, and New York, February 1940.

Wears Longer

EVANSTEEL

for hard service

Costs Less Per Year

EVANSTEEL is a high-strength special alloy with unusual shock and wear-resisting properties . . . economical to use where severe abrasion, impact and vibration are encountered. Important advantages:—

Great strength and toughness
Readily machines to a smooth blemish-free surface
Takes a uniformly high polish
Brinell hardness: 175 to 500—depending on heat treatment

Recommended for vital parts of pulverizing, processing and handling equipment. *Write for Bulletin.*

EVANSTEEL saves on maintenance and replacements for crusher jaws, pulverizer hammers, dipper teeth, drag chains, bucket lips, gears and pinions.

CHICAGO STEEL FOUNDRY COMPANY

PYRASTEEL for high temperatures

KEDZIE AVE & 37TH ST. CHICAGO Makers of Alloy Steel for 30 Years

EVANSTEEL for strength

A New A. C. S. Monograph

PHENOMENA AT THE TEMPERATURE OF LIQUID HELIUM

by E. F. Burton, H. Grayson Smith and J. O. Wilhelm,
Dept. of Physics, University of Toronto

The first book on this intriguing subject!

IT IS of the greatest importance for both physicists and chemists to be familiar with the peculiar action of matter at excessively low temperatures. An understanding of the modern phases of low-temperature research requires discussion of the means of producing low temperatures and of measuring both the temperature and the properties of the substance involved, as well as a general presentation of experimental results already obtained. This fundamental material is given in the early chapters.

The essence of the book is found in the latter half where are presented the results of the impact of curious low-temperature phenomena on modern theories of matter, the nature of superconductivity, the behavior of specific heats and magnetic properties of matter and the freakish antics of liquid helium below 2° K. Particular attention has been given to the definition and measurement of temperature, and to the intriguing problems of the approach to the absolute zero.

The experimental work discussed in this timely book was performed at the McLennan Laboratory in Toronto, one of the best equipped physical laboratories in the world! The authors are pioneers in low-temperature research, and their work will be of the greatest interest to chemists, physicists, engineers and metallurgists.

CONTENTS—Historical Introduction. The Liquefaction of Gases. The Measurement of Temperature. The Physical Properties of Liquid and Solid Helium. Superconductivity. Specific Heats at Low Temperatures. Magnetic Properties. Temperatures Below 1° K. Electrical and Thermal Conductivities. The Nature of the Superconducting State. The Transformation in Liquid Helium and the Nature of Helium II. Appendixes. Author Index. Subject Index.

384 Pages **Illustrated** **Price $6.00**

REINHOLD PUBLISHING CORP., 330 West 42nd Street, New York, U.S.A.

METALLURGICAL ENGINEERING

shop notes

Checking Porosity in Small Castings

by Herbert Chase

The porosity in certain types of castings, die castings as well as sand castings, is not always detectable by ordinary visual inspection because it is below the surface. In many applications, such porosity is not serious, but in others (aircraft parts, for example) porosity is not permitted, and if X-ray examination costs too much to be feasible on each casting, certain other expedients are helpful.

One rapid method of particular use for aluminum or magnesium alloys is to immerse the casting in a solution having virtually the same (but never higher) specific gravity as the alloy of the casting itself. If the casting floats in this solution, porosity is present; if it sinks, it is sound or the porosity is too slight to be of significance. This is an acceptable test for certain die cast parts for aircraft use. If a solution likely to cause corrosion be used, the casting must be removed soon and rinsed thoroughly.

A handier method sometimes used, especially for zinc alloy die castings, is to select a casting known to be sound or sufficiently free from porosity to meet requirements, and either weigh it carefully or use it as the known weight on one side of a balance such as is sometimes used in drug stores—the type with a pair of flat discs, one on each side of the balance. With a known weight or the casting of known soundness on one side, other castings to be checked are placed successively one at a time, on the other side. Those which do not balance properly are rejected. The balance, of course, must be sufficiently sensitive to detect significant differences in weight and yet sturdy enough to retain required accuracy. A good inspector can use such a balance with remarkable rapidity.

Castings made in sand molds are likely to be subject to much more variation in weight, for reasons other than porosity, than are those produced in metal molds. For example, the dimensions of the sand mold may vary slightly even when the closest control is sought, hence a wider weight tolerance may be necessary than for, say, a permanent mold casting. In all cases, whether for sand castings, permanent mold castings or die castings, tolerances on weight should be as liberal as conditions permit and still yield required results. Otherwise, rejections may unduly increase cost without any corresponding benefit.

For die castings, at least, weight limits are not often set and should not be set unless conditions make this practice essential. When they are definitely required, specifications should be explicit, and the foregoing methods of checking weight often prove helpful.

Your editors want this department to become as nearly completely reader-written as possible, so urge anyone who has developed or is using some time-saving, trouble-saving or money-saving operating "kink" to submit it for publication. Payment will be made for all acceptable material that is original in nature—in other words, that has not appeared in print before. —The Editors.

A steel containing 1.10 per cent carbon, 1.75 tungsten, 0.60 chromium and 0.25 vanadium was used for an oil hardening non-deforming punch that produced a total of 135,300 clock-face stampings at one plant before it was replaced.

—*Vanadium Facts*
Vanadium Corp. of America

As a brightening agent in plating cadmium from cyanide baths, glycerine "foots" (the residue from the distillation of glycerine) in quantities of about 2 oz. per gal. produces brighter deposits than goulac, one of the common addition agents. Additional brightening can be achieved by a momentary dip in 1 per cent nitric acid.
—Mathers and Guest, *Trans. Electrochem. Soc.*

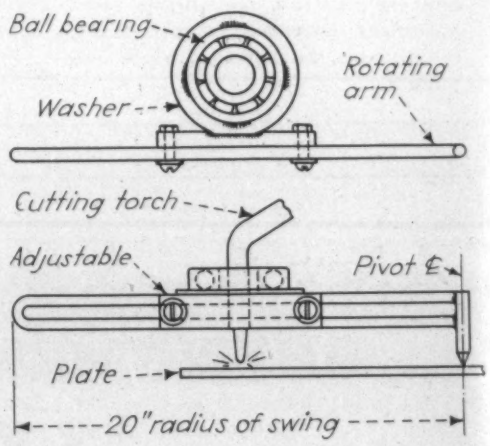
In patching cupola linings, fireclays should be milled in either a pug mill or a muller to insure uniformity and obviate the use of too much water. Also, a small amount of sodium hydroxide—about 1 lb. to 50 gals. of water—used in tempering the fireclay permits working it at a lower water content.

—*Pig Iron Rough Notes*
Sloss-Sheffield Steel & Iron Co.

Circle Cutter for Flame Cutting

by E. P. Rife

The following very simple but unique "circle cutter" used in conjunction with the usual type of oxy-cutting blowpipe has been very satisfactory in keeping the cutting nozzle on the circular line scribed beforehand on the plate or steel object to be cut.



This device can be made of odds and ends around the shop. The materials we used include:

42 in. of ¼ in. steel rod, round or square
1 complete ball bearing and race with shaft hole large enough to slip on the blowpipe nozzle
1 new ¾ in. steel washer
1 piece of 10-gage steel plate about ¾ in. x 2¾ in.
2 3/16 in. stove bolts, nuts and washers
5 or 6 welding rods for light-gage work
1 3¼ in. piece of ¼ in. wear-resistant rod (Lincoln "Toolweld," for example)

With the device illustrated, circles up to 36 in. in diameter can be cut.

—*The Stabilizer*,
Lincoln Electric Co.

Countersunk rivets can be easily removed without damage to the plates by means of the oxyacetylene welding blowpipe if a cutting blowpipe and rivet-cutting nozzles are not available. After the heads have been heated white hot, the rivets are simply knocked out with a hammer and punch.—*Oxy-Acetylene Tips*, Linde Air Products Co.